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DISCOVERY

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A GERM TO KILL A GERM

AGAINST DESTRUCTIVENESS

By The Editor

RUTHERFORD

Being the Life and Letters of the
Rt Hon. Lord Rutherford, O.M.

By A. S. EVE

With a Foreword by EARL BALDWIN

"In 1911 Rutherford introduced the greatest change in our idea of matter since the time of Democritus." This is Sir Arthur Eddington's tribute to Lord Rutherford's personal contribution to science in the field of atomic physics which he made his own; but besides being a great scientist himself, Rutherford stimulated others to carry on original scientific work. His position is unique; in the renaissance of physics which has taken place in the last forty years he is the central figure, and under his direction the Cavendish Laboratory at Cambridge became recognised as the home of research on the structure of the atom. This is the story of Rutherford the man and of his work, told by a friend and colleague who has been content, whenever possible, to let his subject speak for himself, "to hold up a mirror in which he may reveal himself, just as he was, in lectures, books, papers, speeches, portraits, letters, and casual talk". The result is a biography which will appeal to all who are interested in science, or in the really great men of our time. The book is fully illustrated with many informal photographs and a portrait.

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Against Destructiveness

DISCOVERY in wartime will have two purposes: (1) to give news and advice about science as applied to war (for example, scientists have useful information upon diet in a time of scarcity, and in this issue Dr Pirie explains how to avoid the most serious deficiencies); (2) to keep on throwing light upon new knowledge.

The second purpose is, of course, the work for which *Discovery* was begun. It is no less essential now than it was then. A war is no reason for ceasing to think. A war is no reason for ceasing to find pleasure and interest where you are accustomed to find them. If our interests go, then we are degraded altogether; and finally, if the interests of all civilized people are smothered, there is not much hope at the end of the war, whatever the result on the surface.

That is not an imaginary danger. It is one of the profound dangers of all violent ages, and particularly of this one. There are many complex motives which have drawn us, ordinary decent people of England and France, into this war. Some of them are creditable, some not so creditable; on balance, I believe that we could do no other. But, though we need not distrust our main motives, we ought not to conceal from ourselves the most sinister of all, which will grow as the war grows, which resides on one side as well as the other, which smoulders in each of us: that is, the zest in destructiveness for its own sake.

Few of us now—few men who have ever thought about themselves at any time—are entirely free of the feeling that we may be wasting our lives. Occasionally one finds a man who seems to be free of it; they are not uncommon among great scientists; the biography of Rutherford (reviewed on p. 611) shows him busy all his

life in happy creative activity; he escaped, it appears almost completely, the visits of doubt and misgiving that ground at another great scientist, Faraday, in middle life. More rarely still, a great creative artist can find the peace of mind, the *knowledge* that his own work is of absolute significance, that was part of Rutherford. And some people are, of course, by nature born without any tendency to doubt their value in the universe.

DON'T KEEP THIS TO YOURSELF

We believe DISCOVERY *is worth doing, war or no war, and we want it to reach the widest possible audience. You, if you will, can help. People who can be persuaded to look at* DISCOVERY *generally become readers. Will you help to make* DISCOVERY *better known every month, by discussing your copy with your friends? Your friends will do the rest.*

But most of us are not so lucky. Perhaps we are more susceptible to doubt because we are living through one of the great crises in history—possibly through the greatest crisis since the discovery of agriculture brought civilization into being. It is not sure whether we really doubt the value of human achievements more than men living in calmer times; but at any rate the discontent is clearer. And the need to destroy is clearer still—not to destroy for any particular reason, but because men cannot see the use of their own establishments, because they cannot at times avoid hating themselves and their lives. There is a tremendous amount of nihilism seething in the world. It has been given its head by war: or perhaps it helped bring about the war. No one has given enough weight to the deep emotional appeal of the destructiveness in both Communism and Nazism. To many men, they have meant a shattering nihilistic release from the world of everyday. And one ought not to forget the nihilistic fervour with which decent, solid men destroyed every constructive proposal in the years after 1918.

Well, this war will provide destructiveness with a supreme chance. Already it is doing so; no one can have gone through this last month without noticing the *avidity* with which the most worthy citizens have cast away the essential richnesses of civilized life. Art—we never liked it anyway, now we can put it in its place. Science—bits of it may be useful in the war, but the rest obviously ought to stop. Our own work—we want to leave it at the first moment and find something which we know nothing whatever about: we feel immensely efficient in the process. Altogether we can struggle free of the burden of civilized life.

It is exactly that which we must stop ourselves doing. We have to make ourselves believe that there are still things entirely worth our effort. 'War is a bestial madness', wrote Leonardo, and went on, with his cool detachment, designing siege engines for the Duke of Valentino and at the same time beginning his trial sketches for the Mona Lisa. There could not be a better example.

C. P. S.

Vitamins in Wartime

By A. Pirie

"War might even be used to improve the nation's food-supply and to banish from the population diseases due to a deficiency of vitamins."

The purpose of Dr Pirie's article is to analyse the changes in food supply which the war may bring to the people of England, and to show how vitally important the application of scientific knowledge is in present conditions.

DIETARY surveys made all over the world show that even in times of comparative peace most people probably suffer from some degree of vitamin deficiency. In Europe, outbreaks of disease due to acute vitamin shortage no longer occur, but mild deficiencies which cause much ill-health are widespread. A few years ago 83 % of Durham and 87 % of London elementary schoolchildren were found to show some signs of rickets due to a shortage of vitamin D. In Cambridge 30 % of a group of elementary schoolchildren were found to be night-blind owing to vitamin A deficiency. This is the picture in England in times of peace, and it might be thought that it must become yet blacker in times of war. This is not so. In war time, planning of food supplies and distribution is undertaken with an energy and authority unobtainable so far in peace. If these qualities are linked with scientific knowledge the war might even be used to improve the nation's food-supply and to banish from the population diseases due to a deficiency of vitamins.

I am going to assume that acute shortage of food does not occur. The government plans are being made on the assumption that the war will last three years and home production of food is being greatly increased. It seems more likely that the quality of our food may change and that the variety will be less. If we have to meet a situation, either locally or nationally, similar to that which occurred in Spain and still obtains in China, then the vitamin supplies from natural sources can be correspondingly increased.

In 1914 little was known of vitamins; in 1939 we know a great deal. Table I on p. 560 summarizes very roughly the information we need to have before us in order to see how our changed food-supply will affect our vitamin intake.

Children need roughly the same amount of each vitamin as adults. Pure preparations of vitamins A, B_1, PP factor, C and D have all been made and are on the market. The pellagra preventive factor, as it was called, was identified as nicotinic acid in 1937, and one of its first large-scale uses was in the Spanish war when American sympathizers with the Spanish anti-Fascists sent a large amount of nicotinic acid to cure pellagra which had broken out among the brave defenders of Madrid.

Foods which are to be rationed and which are important sources of vitamins are meat and fats. Foods which may become scarce owing to smaller imports are fruits, particularly oranges, and vegetables. Foods which may become scarce and out of reach of the poorer members of the community unless their price is strictly controlled are eggs and fish. The vitamins are distributed among these foods in the following way. Meat, especially liver and kidney, contains vitamin B. Butter contains vitamins A and D. Fruit and vegetables contain C, and carrots and tomatoes can supply A. Eggs contain A, B and D and fish contains A and D.

Normally, therefore, the population obtains quite a lot of its supply of vitamins from foods which it can no longer buy freely, and the supply must be guaranteed in other ways. There are many preparations

of concentrated vitamins on the market, and one way of securing the vitamin supply would be to make these very cheap and to encourage people to take them. This is not a good way, as it is a bother to take pills and most people would refuse or forget to do so. The second way is to increase the vitamin content of foods so that even with a restricted supply people will obtain sufficient.

There is a good deal of evidence from dietary surveys that the population is already slightly deficient in the B vitamins, and as meat is to be restricted this deficiency might be expected to get worse. The other main source of the B vitamins is bread, and this is not rationed. Wholemeal bread contains at least three times as much vitamin as white bread, and to ensure an extra supply of vitamins B to the nation an early change to wholemeal would be a very good plan. A further increase in vitamin content could be made by using larger quantities of vitamin B-rich yeasts in baking. Marmite, a commercial preparation used for flavouring and sandwiches, is rich in vitamin B.

Table I

Vitamin	Source	Daily need	Disease caused by deficiency
A	Fish and mammalian livers. Fats	3·0 mg.	Night blindness. Xerophthalmia. Stunted growth
B_1	Wheat germ, yeast, meat, especially liver and kidney	Up to 4 mg.	Beriberi. Neuritis. Skin affections. Digestive upset
PP factor (nicotinic acid)	Meat. Yeast	Curative dose 500 mg.	Pellagra
C	Fresh and canned fruit and vegetables	25–100 mg.	Scurvy
D	Fish oils. Fats	0·02 mg.	Rickets

The richest sources of vitamins A and D are the liver oils of fish and whales. All the common fishes, like halibut, herring and cod, are very rich in vitamins, and these can be extracted from the livers and added to other manufactured fats. The government has already stated that it has considerable stores of whale oil. It would be very interesting to know whether this includes the liver oil or not. If it does it forms an added source of these two vitamins. Margarine is the obvious food through which the supply of vitamins A and D to the population could be assured. Some brands on the market already contain them, and it should be made compulsory for all margarine to contain sufficient vitamins to ensure that the weekly ration of fat also supplies a minimum weekly ration of vitamins A and D. These two vitamins are stable towards heat and there would be little loss if the fat were used in preparing cakes or pastry. The daily requirements are contained in one-sixth of an ounce or less of crude fish-liver oils, so that it would be possible to add the oils to margarine without affecting the taste.

It is now a standard practice to give orange juice daily to babies and children as a source of vitamin C. Since all our oranges come from abroad we may well be short of them, and other sources must be considered. Potatoes contain some vitamin C, so that the adult population is unlikely to suffer from a serious deficiency unless this crop fails. Alternative sources of vitamin C for children are tomato juice and black currants, either fresh or canned. Black currants in particular are much richer in vitamin C than other garden fruits. If there is any danger of shortage a plan for utilizing hips and haws could easily be worked out. These contain more vitamin C than any other English fruits, and could easily be made into palatable pickles or sauces. Vitamin C is partly destroyed by cooking, particularly if soda

has been added to the cooking water. In acid solution it is heat stable, so that tomato or hip pickles are a good source. A really adequate supply of this vitamin is very important, as there is some evidence that it is, even more than the other vitamins, concerned with the body's resistance to disease. Epidemics are particularly likely to occur in war time owing to the mixing up of the population, and they will probably occur even more readily in a population deficient in vitamin C.

In 1918 our rations were: meat 1½ lb., sugar ½ lb., fat 7 oz., and bacon ¼ lb. per week per person. In 1939 those so far suggested are: meat 1½ lb., sugar ¾ lb., butter and margarine 7 oz., lard 4 oz., bacon 6 oz. With bread, fruit, eggs and cheese unrationed there is no danger of an insufficiency of food, and the only problem at the present time is to balance the diet.

During the last ten years the amount of interest taken in food, either the food of the individual or the food of the community, has enormously increased. Doctors, public health authorities, political parties and charitable organizations have all tried to make people care about the type of food they ate as well as about the quantity. The knowledge they have gained must now be carefully applied if the English population is to be healthy. It can be applied in the isolated kitchen, to a certain extent, but, as I have indicated in this article, it is easier to apply it from the centre so that the food as it is distributed contains sufficient vitamins as well as sufficient calories and proteins. International scientific work has made this possible, and it is to be hoped that the government will be more alive to its value in 1939 than it was in 1914.

Camouflage in Nature

By Harold Bastin

(The art of not being noticed has been brought to the greatest degree of refinement by many otherwise unprotected insects and animals. This article explains, among other things, why nearly all birds are lighter in colour on their underparts, how a caterpillar contrives to look like nothing, and how stick insects have developed a habit of falling into a trance in order to keep still.)

The fact that animals of various kinds are often disguised in their natural haunts in such a way that they are hidden from their enemies has long been familiar to mankind.

The woodcock, the partridge and the wild duck so closely resemble their surroundings when nesting that the wandering naturalist or sportsman will as often as not pass them by unnoticed. This harmonizing by means of colour with the usual surroundings is also seen in the eggs and fledglings of many birds, notably plovers, terns, and certain gulls, which nest on the bare ground, or among shingle above high-water mark on the sea coast.

Probably the pioneer in what we may term the analytical method of colour interpretation was Professor E. B. Poulton, who described in detail how certain caterpillars and pupae are, by a method which he called "shadow-neutralization", rendered far less conspicuous than they would be if their colours were precisely similar with those of their surroundings. For example, the green pupa of the purple emperor butterfly looks like a sallow leaf, although it is actually many times thicker. How is

When camouflage is of first importance. Birds on the nest. Ptarmigan, above, and, below, the Ringed Plover

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this deceptive impression of flatness conveyed? By a process exactly analogous to stippling—large numbers of minute white dots occurring on the otherwise green surface of the pupa at exactly those places where its rotundity, if obvious to the observer, would destroy the resemblance to a leaf. In this manner "the roundness is neutralized by increased lightness, so disposed as just to compensate for the shadow by which alone we judge of the roundness of small objects".

The recognition of this important fact, that general protective resemblance is not merely a matter of appropriate colouring, but also of appropriate disposition of light and shade, was greatly aided by the work of the American artist-naturalist, Abbot H. Thayer. He showed, in the first place, that the presence of an animal, even if its tints accord perfectly with the colours of the background against which it is seen, would be betrayed to its enemies by the sharpness of its outline, or by the shadow which it casts. Now a human artist, by the process known as "shading", which is really a painting in of shadow, produces the deceptive appearance of relief, or solidity, on his flat canvas. Having the trained eye of an artist, Thayer was able to demonstrate that Nature often achieves her effects by a reversal of this method. She paints out shadows, with the result that the appearance of solidity is effaced. To illustrate his theory in its bearing upon the coloration of certain large animals and birds, Thayer constructed models (replicas of which are now to be seen in most of our museums of natural history) by means of which he proved that a creature which is dark on the back, shading through increasing paleness on the sides to white beneath, is far less conspicuous than one that is uniformly coloured all over, even though its general tinting may harmonize exactly with its surroundings. Briefly, the model consists of a box, the top and one side of which are glass. It is, in fact, a little stage lit from above, and contains a couple of dummy duck-like birds supported on a rod running from side to side across the box, at right angles to the observer's line of sight. Both the dummy birds are covered with the same grey material with which the box is lined.

The caterpillar Cucullia artemisiae

The Stick Caterpillar (*Raspberry looper*)

One is otherwise uncoloured, and is rendered very conspicuous by the illumination of its back, and the heavy shading of its under surface—thus showing that mere identity between the colour of a creature and its surroundings does not afford protection, but rather the reverse. The other dummy is skilfully painted with a dark tint above, shading to white beneath, with the result that an effect of flatness and unreality is produced. At a distance of only four feet, in a good light, the model bird is practically invisible. Yet if a sheet of paper is held over this dummy, so as to cut off the top-light falling upon it, it immediately becomes solid and real to the observer who a moment previously had been unable to detect more than the faintest suggestion of its outline.

In many instances the colours of a creature are quite obviously protective; but in many others a good deal of careful observation and experiment is necessary before the fact can be clearly demonstrated—because at first glance the subject under consideration may seem too showily coloured to escape notice, even among its customary surroundings. In the earlier stages of its development, the caterpillar of the puss moth feeds chiefly at night, and rests during the day, in full view, upon the upper surface of a leaf, where—thanks to its coloration—it has the appearance of a hole torn or nibbled in the substance of the leaf. The caterpillar actually passes itself off as a gap—nothingness! But in the final stage of its development, before changing to the pupa, it hangs head downwards either from the edge of a leaf, or from a leaf-stalk. Its bulk is now considerable, and its colouring may be described as pure leaf-green below, separated by a thin whitish line from the long dorsal "saddle" which ranges in tint from purple to purple-grey or cream. If one judged solely by this description, one might suppose that extreme conspicuousness was the end that Nature had in view when planning this colour scheme. Yet in truth the puss moth's caterpillar is most wonderfully hidden when in its customary environment. Without entering too far into technical details it would be impossible to describe adequately the perfect artistry by which this end has been achieved. Suffice it to say that when seen laterally the caterpillar presents the appearance of "two green leaves against a background of purple bark or shade; while in a horizontal position... the dorsal saddle is an accurate copy of the slightly upturned tip of a fore-shortened leaf. So good is either resemblance that workmen shown the full-grown larvae at two feet distance failed to detect them, or to recognize a

The Lichen Moth ——→

Another stick caterpillar, the Broom looper

caterpillar till convinced by the evidence of touch."

It had long been remarked by naturalists that some animals, when lying motionless in an exposed situation, are not only protected by their own colour scheme in so far as it "matches" the background, but derive also a certain benefit from the presence of any conspicuous object which may be near them. Indeed, there is some reason for thinking that birds and beasts, and even insects, habitually come to rest at a spot where such extraneous protection is available—as, for instance, close to the strong light reflected by a white stone, or from the surface of still water. Thus, the snipe is said by sportsmen commonly to lie near a tiny pond, or close to the margin of a pond or river. In such places the strong white reflexion tends, by its very brilliance, to conceal all relatively sombre objects in the immediate vicinity. The eye of an observer is dazzled by an excess of illumination and fails to detect details that would be clearly enough visible in other circumstances. Moreover, it is a fact that light-coloured objects tend to arrest and hold both the eye and the attention, with the result that neighbouring objects of less luminosity are overlooked. Now Thayer pointed out that facts such as these supply us with a plausible clue to the "meaning" of the pale-coloured spots and patches so often seen on the wings of moths and other insects. In all other respects, the wings may be marvels of protective colouring; and one might be inclined, at first, to suppose that the conspicuous marks must needs detract from this concealing effect. Yet the reverse is apparently the case; for it is possible to show by actual experiment, as Thayer did, that by riveting the observer's gaze, they actually prevent him from detecting the insect's outline, which is always the weak point in a disguise. Thanks to these pale spots, it is difficult to perceive where the surface of the bark or stone, upon which the moth is resting, ends, and where the imitation (i.e. the insect's wings) begins!

Sometimes the disguise, when critically considered, proves to depend wholly upon a deft arrangement of colours, as, for instance, in the case of our charming orange-tip butterfly, the underside of whose hind-wings (which fold over and conceal the other wings when the insect is resting) are so tinted with a mottling of green and white that the semblance of a cluster of tiny flowers is produced—flowers like those of the common hedge garlic, which is one of the butterfly's food-plants. On the other hand, the effectiveness of the resemblance may be due in part to the colour, but still

Pine-hawk Moth ——→

The caterpillar of the Pine Beauty Moth

more to the form of the creature in question. Stick insects, and crabs which look like pebbles, are cases in point; so also are the lappet and buff-tip moths, the former, when resting, being the "living image" of a tuft of withered oak leaves, while the latter—as the outcome of the unusual manner in which it folds its wings—exactly reproduces a broken bit of birch twig, partially decayed.

One point more may be stressed: protective coloured creatures, if their disguise is to prove successful, must keep still. Immediately the stick insect begins to creep, or the leaf-like butterfly to flutter its wings, the resemblance ceases to be convincing. In this connexion it is interesting to note that some insects are able to pass into a state of trance, which continues during the normal resting period. This fact was first demonstrated in regard to a particular species of stick insect which feeds at night, and during the hours of daylight rests motionless with extended limbs among the twigs of its food plant. On these occasions it was found to be not merely asleep, but to have passed into a condition of catalepsy from which it could be aroused only after long-continued stimulation. Although the question has not received the close attention which it deserves, we have some reason for supposing that many insects pass periodically into a state of self-induced trance, more or less complete; and that they are thus held, automatically, so to speak, in the particular motionless pose upon the maintenance of which their protective resemblance to surrounding objects ultimately depends.

Monomolecular Layers

By E. E. Widdowson

By a simple and ingenious method, Drs Blodgett and Langmuir first deposited monomolecular layers on a solid surface. In this article, Dr E. E. Widdowson, lecturer in physics at University College, Hull, describes the experiment and explains the building up of molecular films, pointing out that the study of their structure may help to throw some light on the difficult problem of protein structure. (Readers will remember a note on this subject in the April number.)

"If a drop of oil is put on a highly polished marble table, or on a looking glass that lies horizontally, the drop remains in its place, spreading very little. But when put on water, it spreads instantly, many feet round, becoming so thin as to produce the prismatic colours for a considerable space, and beyond them so much thinner as to become invisible." In this way Benjamin Franklin recorded his observations on surface films in a letter to William Brownrigg in 1773. In 1899, by measuring the volume of the drop of oil and the area to which it would spread on a water surface, Lord Rayleigh estimated the thickness of the "invisible layer" to be one-millionth of a millimetre; he suggested that this "perhaps hardly exceeds at all the diameter attributed to a molecule of oil".

Numerous more recent experiments have confirmed the fact that the oil does indeed spread until a monomolecular layer is formed, any surplus oil remaining as drops or "lenses" on the surface. The oil molecules are so much more strongly attracted to the water surface than to each other, that as many as possible of them lie on this surface, excess molecules remaining tightly packed together owing to their own attractions. If the area of the surface is decreased or increased the drops grow or diminish accordingly, the monomolecular layer always covering the entire available surface. This spreading may be very easily observed by dipping a finger into the surface of a bowl of clean water, on which talc powder has been scattered. More spectacular results may be obtained with a drop of oil; but sufficient grease is present on the finger to form a large monomolecular layer, behind the boundary of which the talc retreats rapidly.

Besides these "liquid" surface films, "solid" monomolecular films of certain substances can be prepared. If a substance whose molecules consist of long chains, such as one of the fatty acids from which soaps are derived, is dissolved in benzene or petroleum ether, and a little of the—very dilute—solution dropped on to a clean water surface, spreading takes place as in the case of oil, but the solvent evaporates rapidly, leaving a monomolecular layer of the fatty acid, the chains lying more or less parallel to each other and at right angles to the water surface. Any surplus molecules after the first layer form themselves into a "macroscopic" visible layer, and this film differs from the "liquid" oil film in that any decrease in the surface area causes the film to crumple up.

Both these types of monomolecular film have been known for some time, and for many years attempts were made to transfer them to *solid* surfaces. It was easy to transfer one or two layers of a fatty acid on to a piece of glass or metal by dipping the latter into a water surface covered with the film, but subsequent layers were torn off during the next dip and returned to the water surface. This can easily be demonstrated by dipping a piece of clean paper several times into a water surface sprinkled with talc and contaminated with a grease

film from the fingers as mentioned earlier. It is clear that some force is necessary to *push* the layers after the first on to the dipped surface and so to prevent their return to the water surface. This was finally accomplished in 1935 by a simple and ingenious method devised by Dr Blodgett and Dr Langmuir in New York.

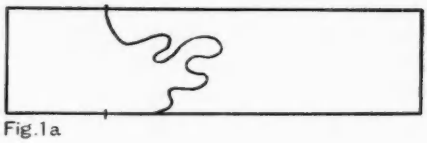


Fig. 1a

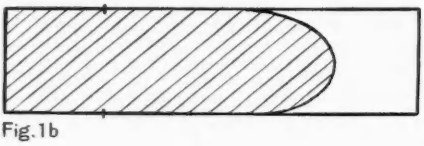


Fig. 1b

Fig. 1c

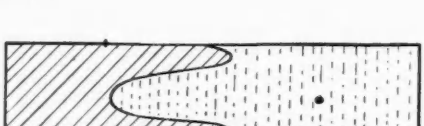


Fig. 1d

Fig. 1

A large rectangular trough is filled to overflowing with distilled water made slightly acid (*p*H 3) and the surface cleaned from grease from the air, etc., by repeatedly "sweeping" or "scraping" it with strips of stout paper moved slowly from one end of the trough to the other. A piece of waxed sewing silk is then floated on the surface with the ends clipped to the sides of the trough (Fig. 1*a*). On the left-hand side of the silk a dilute solution of, say, stearic acid in petroleum ether is lowered on to the water surface drop by drop, when the silk is observed to bow out owing to the pressure exerted by the film of stearic acid, which cannot escape to the right-hand side of the waxed thread. When the thread is bowed out (Fig. 1*b*), a drop of olive oil is placed on the surface to the right of the thread. The oil immediately spreads, exerting a pressure great enough to push the stearic acid molecules more tightly together so that the silk is pushed back a little (Fig. 1*c*), and any surplus oil forms a lens on the surface. It must be borne in mind that there is no mixing of the two films, which are entirely separated by the thread. Now if a suitably prepared glass or metal plate is dipped vertically through the stearic acid surface, some of the film is pushed on to it by the (constant) pressure exerted by the olive oil on the other side of the thread. The silk moves to the left each time the plate is lowered or raised through the surface (Fig. 1*d*). The decrease in area on the left-hand side of the silk corresponds to the accumulated area of the plate immersed. The process is shown diagrammatically in Fig. 2. The stearic acid molecules (CH_3) (CH_2CH_2. . . 17 times) (COOH) on the water surface have their tails (CH_3) uppermost and their heads (COOH) downwards. The length of each molecule is about 2×10^{-7} cm., and the deposited layers face alternately in opposite directions, one being deposited on the plate at each lowering or raising through the water surface.

By the application of this method, using floating silk as a two-dimensional piston with a constant pressure behind it due to the liquid film of olive oil, hundreds and in some cases thousands of molecular layers can be deposited. Various substances have been used, other fatty acids and their salts, and esters and proteins.

Fig. 3 shows a trough and dipping arrangement after a number of layers of stearic acid have been deposited on stainless steel (corresponding to Fig. 1*d*). The

olive oil is at the front end of the trough, and the thread separating it from the stearic acid behind it is visible. On the steel plate supported above the trough by the dipping arrangement, three horizontal bands may be seen; they show where 30, 50 and 70 layers have been deposited.

As a polished metal plate is repeatedly dipped through the surface, the built-up film on it becomes coloured, first yellow-brown, then cherry-coloured, magenta, turquoise blue, and so on. These colours are much more vivid when viewed in polarized light, and under suitable conditions they are brilliant. They are of course interference colours—Franklin's prismatic colours—and are produced by the reflexion of light from the air-film and the film-metal boundaries. They are similar to the colours exhibited by petrol spilt on a wet road, which spreads out into a layer not many molecules thick. The molecules in the built-up films are oriented, arranged in a pattern of parallel layers of chains: they constitute an artificially constructed crystal. It is because of their orientation that polarized light (in which the vibration is oriented, being confined to one plane) produces such marked colours; and by altering the plane of polarization and the angle of incidence, the colours are changed. These colours provide an excellent method for determining the thickness of a built-up film, and in the red-blue region where the change is most rapid, a difference of one or two layers produces a noticeable colour change.

If a platinum wire carrying a speck of protein such as egg albumin is dipped into a clean water surface, the protein spreads over the surface forming a monomolecular layer, but in this case the polypeptide chains lie *along* the water surface, with their side chains dipping into the water. Protein films have been transferred to metal in the same way as films of fatty acids and their salts, and in 1938 W. T. Astbury and his collaborators succeeded in preparing a built-up film consisting of 1765 monolayers of egg albumin. The final film, which was nearly 0·002 mm. thick, was stripped from its metal base and studied in various ways. The most spectacular of these consisted in folding it over so many times that a thickness was reached which could be measured with an ordinary screw micrometer! Examination by other methods showed that the films were *fibrous*, the fibres lying along the direction in which the

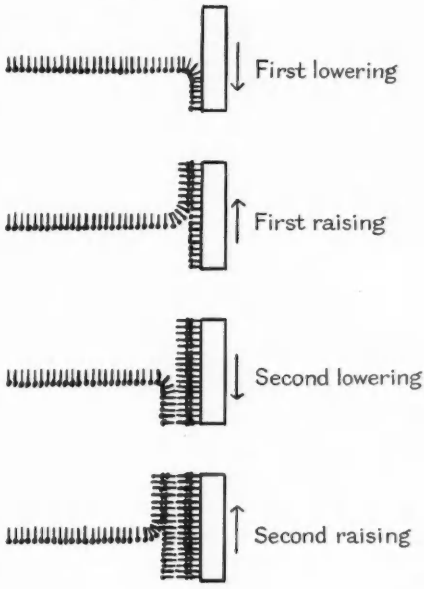


Fig. 2

metal was moved through the water surface. Moreover, it was shown that the fibre structure was already present in the film spread out on the water, the fibres becoming oriented as transference to the metal took place. The study of built-up films of proteins may elucidate considerably the difficult problem of protein structure; moreover, as methods are devised for preparing multimolecular films of other types of molecules, much further information should be brought to light.

One of the most promising applications of these built-up films is due to their optical properties. In 1892 it was discovered

that a tarnished lens transmits more light than a new one, and during the Great War, Kollmorgen succeeded in reducing the surface reflexion in gunsights by chemical treatment resulting in a suitable surface film. In 1935 Strong reduced the unwanted reflexion to less than half by coating

Fig. 3

glass with evaporated films of fluorite, and in 1938 Blodgett succeeded in raising the transmission of glass for white light from 92 to 99·2 %, by the use of specially prepared built-up films. The unwanted reflexion from glass surfaces has always presented a great problem to optical instrument makers, since it occurs at every surface in the instrument, and in an instrument containing ten lenses, less than a quarter of the incident light may eventually reach the eye. In an average pair of small prism binoculars about half the light is lost in this way.

Blodgett's method of preparing the films consists of building up films of cadmium arachidate and dissolving out in benzene the arachidic acid which is always present in the films unless the water in the trough is alkaline, so that a "skeleton" film is produced. This skeleton film has a lower refractive index than the original film, and by adjusting experimental conditions any refractive index (μ), between certain limits, may be obtained. Skeletonized films on glass have in general more marked optical effects than directly deposited films because the refractive index of the latter is so nearly equal to that of glass, while the process of skeletonizing reduces the refractive index. For example, for microscope slides $\mu = 1{\cdot}52$, for calcium arachidate $\mu = 1{\cdot}54$, while for skeletonized calcium arachidate μ may be reduced to 1·2. The optical condition for minimum reflexion at the glass surface is $\frac{\mu_{film}}{\mu_{glass}} = \frac{\mu_{air}}{\mu_{film}}$, so that for the glass under consideration μ_{film} should be 1·23, which can easily be obtained.

Other properties of these films can only be enumerated briefly. Films deposited under certain conditions exhibit a surface potential which is built up with the films and is proportional to the number of layers, and fairly appreciable voltages may be obtained in this way. The films may be used as exceedingly thin absorbing screens for radioactive atoms, which penetrate through less than a hundred of them in recoiling after the emission of an alpha-particle. They may be skeletonized by evaporation as well as by dissolution, and this also opens up a large field for investigation.

Notes of the Month

ENERGY FROM MATTER: SOME RECENT DEVELOPMENTS

In the September number of *Discovery* an outline was given of research now being made on the fission of the uranium nucleus by bombardment with slow neutrons. Mention was made of the possible development of a "chain reaction", with the production of high energies—in other words, the possible realization of the dream of atomic power. The importance of this research was emphasized, as it may lead to the development of an explosive a million times more powerful than dynamite, or a fuel thousands of times more powerful than those now known.

News has recently come to hand of further work on this subject made by Professor E. Fermi and his collaborators in New York. They have succeeded in showing that when a uranium nucleus absorbs a neutron, on the average about one and a half neutrons are emitted. They have distinguished, however, between two types of absorption. There is the absorption of slow ("thermal") neutrons which produces the effect mentioned, and there is the absorption of fast neutrons, in which case no fission occurs and no neutrons are emitted. This latter process is known as "resonance absorption".

But the neutrons emitted by uranium following the absorption of slow neutrons are fast ones, and therefore, to produce a "chain reaction", in which the neutrons given out by one atom of uranium can be used to excite the next, the uranium must be mixed with some other element to slow down the fast neutrons emitted until they reach thermal energies. The element used in Fermi's experiments was hydrogen, obtained by mixing the uranium compound with water. In such a system, absorption of neutrons can take place in three different ways. Fast neutrons can be absorbed by the uranium at "resonance"; slow neutrons can be absorbed by the hydrogen, or slow neutrons can be absorbed by the uranium, liberating energy and further neutrons. It is this latter effect which must be encouraged.

In the experiments performed, the concentration of hydrogen to that of uranium was in the ratio of 17 : 1. In such a case, most of the slow neutrons are absorbed by the hydrogen, and there are insufficient left to set up a chain reaction. On the other hand, if there is too little hydrogen, the fast neutrons emitted by an exploding nucleus will not be slowed down, but will be wastefully absorbed by the uranium at resonance, and again there will be no chain reaction.

The New York scientists are now trying to find out if, when the ratio of the hydrogen to the uranium is at its optimum value, there will be sufficient slow neutrons reaching neighbouring atoms to set up a chain reaction. It is impossible to make any prediction on theoretical grounds, as the data about "resonance absorption" is at present insufficient.

If such a chain reaction is started, then all our hopes and fears will be confirmed: if not, we can breathe easy for a while—until some diluent more suitable than hydrogen is discovered!

D. W. F. M.

(*Anderson, Fermi and Szilard, Columbia University, New York*)

A NEW TECHNIQUE FOR MINERAL PROSPECTING

TWO Swedish scientists, Dr Nils Brundin and Dr Sven Palmgrist, have developed a new method of detecting the presence of minerals in the soil from the analysis of trees growing in the area. It is well known, of course, that plants absorb mineral salts indiscriminately from the soil, regardless of whether they are essential for growth or not. (A classic example being the element selenium, which has been known to be absorbed in such quantities that sheep eating the plants have been poisoned.) It is also clear that any element present in the leaves of trees and plants must have been derived from the soil.

The method is intended as a pointer, and would be a valuable adjunct to existing methods which include boring, magnetic and electric surveying. In all cases a bore would be necessary before the quantities in which the mineral occurred could be determined. It is particularly suited to areas such as the forest regions of the tropics where it is difficult to carry out a trial bore.

W. E. D.

(*Science News Service*)

A GERM TO CATCH A GERM

SEVERAL years ago, Dr R. J. Dubos, a research worker in the Rockefeller Institute of New York, isolated a bacillus from the soil which was capable of dissolving the capsule of certain pneumonia bacteria. He was able to get an extract from this which could protect mice from infection by these pneumonia organisms. Recently, Dr Dubos has reported a considerable advance along these lines. He was able to "adapt" his soil bacilli to attack various disease-producing organisms by adding to the soil continually for several months small quantities of these germs, and was eventually able to isolate an adapted bacillus which was capable of completely breaking up and dissolving live bacteria of several species. He was also able to obtain from the soil bacilli a solution containing the active principle, which attacks streptococci (responsible for diseases such as erysipelas, scarlet fever and "blood poisoning"), staphylococci (responsible for boils) and pneumococci (the organism responsible for pneumonia). The tremendous activity of the substance can be appreciated when it is realized that 1 mg. (1/30,000 oz.) of the dried extract can destroy one thousand million live pneumococci. Twice this amount will protect mice which have been injected with enough pneumococci to kill 100,000.

The extract has so far not been tried on man, but the potentialities are tremendous. It may even prove possible to isolate organisms and their extracts which would be capable of destroying other pathogenic organisms such as those causing tuberculosis.

J. Y.

(*R. J. Dubos, New York*)

SOUND REPRODUCTION ON PAPER

A SYSTEM of reproducing sound by means of paper originated by the Russian inventor Skvortsov, who died before the experimental work was completed, has been so far perfected that a recording has been made of one of the Mark Twain's stories.

According to *Russia To-day* sound waves, increased by the usual methods of a film, are printed and duplicated on ordinary paper. To produce the sound, a ray of light follows the sound track, passing through it and falling on to a photo-cell in a light stream of varying intensity. The photo-cell transforms the light waves into electrical waves, which in turn are transformed into sound waves by means of a wireless amplifier. It is estimated that under mass production a paper phonogram giving an hour's sound reproduction would cost one-fifteenth of the cost of an equivalent quantity of gramophone records and one two-hundredth part of the cost of a celluloid sound film giving an hour of sound reproduction. A paper phonogram would occupy one-fiftieth of the space of a celluloid film, which is an important transport factor. A paper phonogram can be played three or four thousand times, whereas a sound film will give only a thousand reproductions, and a gramophone disk even fewer. Another advantage is that, in the case of paper, thousands of positives can be printed from one negative, whereas celluloid film negative will only allow of a few dozen positives being printed from it. By means of the paper phonogram, thousands of copies of speeches, lectures and any kind of music can be supplied to the public within twenty-four hours of the original performance.

N. K. S. G.

(*Science & Culture*)

PHOTOSYNTHESIS WITH INORGANIC CATALYSTS

It is well known that green plants are able to utilize the energy of sunlight to transform carbon dioxide absorbed from the atmosphere, and water, into carbohydrates. This reaction (photosynthesis) is, of course, fundamental in plant, and indirectly in animal, life, and has therefore received a great deal of attention. In plants the green colouring matter, chlorophyll, plays an essential part as a catalyst and as a substance able to absorb the incident light. But although the structure of this compound is now known with some certainty, the exact mechanism by which the reduction of CO_2 to carbohydrates occurs has not yet been established.

Naturally enough, the possibility of producing carbohydrates and other organic bodies by photosynthesis *in vitro* with inorganic catalysts instead of chlorophyll has been a matter of interest for a long time. Some years ago, Professor Baly of Liverpool described experiments in which small quantities of organic substances were formed by shining white light on a suspension of nickel or cobalt carbonate in water saturated with CO_2. As these carbonates are coloured, they must absorb some of the light falling on them, and it appears from these results that radiation absorbed in this way can bring about the reduction of CO_2.

Some attempts by Baly and by others to repeat this work unaccountably failed to give the slightest trace of carbohydrates or other organic bodies. In a recent paper, however, he gives details of some fresh experiments on the same lines which have this time yielded positive results. The catalyst used is nickel carbonate, "promoted" by the addition of one part in twenty-four of thorium dioxide. It is precipitated in the presence of a suspension of kieselguhr, and forms an active layer on the surface of the kieselguhr particles. This catalyst must be prepared with great care. It is very easily poisoned by traces of alkalis, and this may explain the failure of some of the earlier experiments.

When the catalyst is suspended in water

saturated with CO_2 and illuminated with white light, detectable quantities of organic compounds soon make their appearance in the solution. Unfortunately, the total amount formed does not increase beyond a small limiting value. This is probably due to the catalyst becoming poisoned by one or other of the reaction products. It has also been found that, on standing, the initial product changes into another compound, which can be obtained in small quantities (0·03 g.) by evaporation of the solution. It is a white solid, and has many of the properties of a starch.

The practical value of these results is clearly negligible at present, but processes of this type may have interesting possibilities in the future.

J. N. A.

(*Baly, Liverpool*)

RECENT IMPROVEMENTS IN PLYWOODS

WOOD, in its natural form, is an unstable substance and easily affected by changes of temperature and humidity. It lacks uniformity of structure and is readily attacked by parasites, like insects and fungi.

For most engineering requirements, high mechanical strength, freedom from corrosion and abrasion and low-water absorption are essential.

Recent advances in the technical field, utilizing new types of synthetic resin for impregnation and for glueing, have succeeded in transforming wood into a material with a strength and stability comparable to metal, without being heavy, and with the excellent insulating properties of rubber, without being elastic in the sense that rubber is elastic. By coating sheets of paper with synthetic resin and interleaving these sheets between thin plys of birch and other wood and subjecting the block, which may be several inches thick, to a high pressure and temperature in a huge hydraulic press, a new variety of material is obtained, which is enormously strong, quite waterproof, absolutely uniform in structure and proof against attack by all parasites.

In place of the bakelite type of resin which is already used for this purpose, a still newer resin, known as Lauxite, has been discovered. This resin is quite colourless and when mixed with a very small quantity of water and spread between the plys, which are generally built up with the grain running in diverse directions, a much lower temperature may be used and a very much shorter time in the press to produce a final result, which by virtue of the fact that the resin has been transformed into an infusible and insoluble substance, is more fire-resistant than ordinary wood and may be readily machined into any desired shape. The density of these treated woods is greater than that of water and is generally of the order of 1·4, water being 1. Where resistance to traction flexion is required, the blocks are made with the fibres all running in the same direction and, therefore, resembling wood in this respect. The product is used for the manufacture of pieces of great resistance, such as insulating fish-plates for railway tracks, as well as for textile accessories, flooring, gear wheels and so on. When the layers are assembled with the fibres crossing at right angles, a material of maximum resistance to pressure and shearing is obtained, suitable for friction rollers, pulleys and bearings. When the layers cross at 45° or less, a substantially homogeneous material is obtained, with properties practically the same in all directions. This is, therefore, the best material to use for making rollers and noiseless gears.

This material can be worked like hard wood on ordinary wood-working machines, or like soft steel with ordinary high-speed

tools. It can be assembled with rivets, wood screws, metal screws, or glue, but it is very difficult to nail. For the manufacture of carriage floors and sides, lift floors, escalators, we well as, of course, for all aeroplane construction, it would be difficult to find a better material. In the shipbuilding industry, where it has not yet been tried, even experimentally, it is probable that this material could replace much of the wood and metal now used. As it is nearly splinter-proof, it could be used on battleships for cabin construction, furniture, panelling and other places where metal or teak is now employed.

H. COURTNEY BRYSON

A NEW INDUSTRY AND A NEW TEXTILE FROM SODIUM ALGINATE

DURING his experiments on the extraction of iodine from seaweed in 1883, E. C. C. Stanford first discovered alginic acid and its extraordinary gelling powers. This gelling power, that is, the ability to transform various solutions to a jelly, soon aroused great interest, but some forty years elapsed before the commercial possibilities of this academic experiment were recognized and the foundations of a new industry firmly laid.

The very wide uses of jelly and gelling agents in industry are not generally known. They are, however, necessary constituents of many foodstuffs and medicines. Most of the jelly used in this country consists of agar-agar, and the vast quantities of this imported yearly into Great Britain come entirely from Japan. It is obviously advisable to have a substance available which can take the place of agar-agar should supplies be cut off, and it is reassuring to know that sodium alginate, the simple derivative of alginic acid which is made here, can fill this need. It was recently successfully used instead of agar-agar in some million tubes of tannic acid jelly manufactured for A.R.P. purposes.

On the rugged west coasts of Scotland and Ireland, there grow in profuse masses hundreds of tons of *Laminaria hyperborea*, the seaweed from which sodium alginate is obtained. It is collected there, brought to the factory and converted by chemical treatment into its commercial derivative. A jelly is prepared by dissolving its concentrated form in hot water and then allowing the solution to cool, the setting being entirely dependent on temperature. But it is just in this condition of setting that the properties of sodium alginate differ, and are, indeed, unique. When the compound, sodium alginate, is dissolved in cold water, even a very dilute solution, say 1 %, will form an intensely viscous liquid which will not set to a jelly. But the moment the slightest trace of a compound containing calcium is added, a firm jelly is obtained. It is thus quite immaterial at what temperature gelation takes place; a solution will set to a jelly as easily in hot as in cold water, and it is this property which makes sodium alginate easy to handle and control.

It is expected that the application of sodium alginate as a new textile will be very successful; this textile is soft, pliant, and of pleasing appearance, and is apparently greatly superior to the Japanese product. Success in the commercial production of moisture-proof transparent paper is also reported from the research laboratories at Oldbury and Maidenhead.

B. V. DE G.

Biological Control

By J. D. U. Ward

This year marks the jubilee of the first scientifically conducted biological control experiment to be brought to a successful issue.

True, the mongoose was introduced into Jamaica in 1872 to control rats, but that essay in applied biology was not particularly scientific: the mongoose, multiplying, soon destroyed many of the island's lizards and wild birds, to say nothing of vast numbers of domestic poultry. At an even earlier date there had been some interesting efforts of a similar haphazard and improvident kind on Sable Island, off the coast of Nova Scotia. But conditions on a small island with a strictly limited fauna are comparatively simple, and such success as was achieved seems to have been due to good luck rather than to precaution or good management.* Except in quite extraordinary circumstances, mammals are too promiscuous in their feeding habits to be satisfactory agents in deliberate biological control: toads and fish have occasionally proved useful, but the vast majority of successful biological control campaigns have been conducted with insects.

This method of tackling pests is—as the fiftieth anniversary suggests—a development of modern science. The observation of John Worlidge, Gent., in 1678—"Bees and silkworms are the only insects that are kept and nourished by Mankind, for their use and benefit"—remained true for virtually three centuries. Swift's remark that the large flea "hath smaller fleas that on him prey" shows that that much was known in his time, and it may properly be recalled that in 1816 Kirby and Spence recognized that if ladybirds could be multiplied, the aphids attacking hops and other plants might be controlled. But the first practical effort seems to have been the introduction, in 1873, of a mite from North America to prey upon a pest which at that time afflicted Europe's vineyards. The mite was established but failed to control the pest. Sixteen years later, however, the successful campaign against another pest was opened in California.

Orange trees, imported from Australia, had taken with them the cottony cushion scale. This insect, unnoticed at first, quickly spread in California, where it was not controlled by predators or parasites. Soon it threatened to wipe out the citrus-growing industry in the West. In 1889, however, *Vedalia cardinalis*, the black and red ladybird which preyed upon the scale in Australia, was introduced from that continent to California. This predator soon established

* Extracts from "Notes on Sable Island", by Simon D. Macdonald, in *Proceedings and Transactions of the Nova Scotian Institute of Natural Science*, vol. VI, part 1, for 1883, p. 22.

"The English rabbit has at different periods been very numerous, and threatened at one time to overrun the Island. But, to their misfortune, the Norway rat landed from an old vessel, and in a short time became so numerous that they nearly annihilated the rabbits, and then turned their attention to the stores of the Island, so that during one winter the staff were without bread for some months. In the spring the Government sent a detachment of cats to look after the rats. The cats killed the rats and then finished the remaining rabbits. In a short time the cats became so wild and numerous as to be a source of danger, when dogs were sent to hunt the cats, and with the assistance of shot guns in the hands of the staff, the cats were finally extirpated.

"Again the island was stocked with rabbits, when a snowy owl found his way thither, and being so delighted at his find, disappeared, and in a few days returned with his friends, who remained long after the rabbits were extinct, and still shows his kind remembrances by making periodical visits."

For this detailed reference and transcription the author is indebted to the Curator of the Provincial Museum, Halifax, N.S.

This apparently hopeless overgrowth was cleared by Cactoblastis *in two years*

lished control of the cottony cushion scale, and so California's citrus industry was saved. During the last fifty years *V. cardinalis* has fed to good effect in New England, Portugal, southern France, Italy, Syria, Egypt, South Africa, Formosa and Hawaii.

Most successful biological control campaigns have been conducted in this way, against insect pests, with predaceous or parasitic insects. But plant pests have also been biologically controlled with insects. The first notable success against a plant pest was achieved between 1902 and 1912, with various insects (twenty-three species were used and eight proved to be of some account) which destroyed the weed lantana and thus saved Hawaii's sugar industry. Subsequently, prickly pear or cactus in Ceylon and southern India was controlled with phytophagous insects (cochineals for the most part); the pernicious piri-piri burr in New Zealand has been attacked with a Chilean sawfly; gorse in the same country has been deliberately infected with destructive weevils; and the ragwort plague there has been tackled with the cinnabar moth and the ragwort seedfly; various insects have been introduced into Australia to destroy St John's Wort, there known as "the racecourse weed"; bramble control with *Coroebus rubi* has been considered if not attempted; and the greatest of all biological control victories yet achieved has there been recorded against a plant pest—prickly pear.

Before something more is said of the prickly pear victory in Australia, it may be noted that *Coroebus rubi*, a beetle which comes from the Mediterranean area,

The prickly pear infected with cochineal

devours some 60 % of new bramble growth but is the less satisfactory as a controlling agent because it is also fond of rose and loganberry bushes. This illustrates well the greatest difficulty in the control of plant pests: entomologists have to make sure that any phytophagous or plant-eating insects they employ are selective in their tastes: that is, the insects must not have—as mammals have—a catholic appetite, which prompts them to turn to food other than that which they are intended to consume. An ideal controlling agent dies of starvation as soon as its special food is exhausted. An insect—even a phytophagous insect—may, however, be too highly selective in its tastes, as the entomologists working on the prickly pear problem in Australia discovered.

Prickly pear—that is, various kinds of American and West Indian cacti—was introduced into Australia in 1788 apparently at the instance of the British Government, who wished to establish the cochineal industry and thus break what was a monopoly of the Spaniards and Portuguese. By 1870 the prickly pear had increased to such an extent that it was recognized as a nuisance, and shortly before the Great War entomologists were seeking insects to control it. In the year 1914 they found in the Botanic Gardens at La Plata a two inches long caterpillar, orange-red banded with black. They tried to establish this caterpillar, a cactus-eater known as *Cactoblastis cactorum*, in Australia. The effort failed. Seven years later the prickly pear problem seemed further than ever from solution. It was computed that 60,000,000 acres were affected and that the pest was colonizing another 1,000,000 acres every year. Desperate attempts were made to check the nuisance. Cactophagous rats and snails could not be used because these creatures also ate plants other than cactus. A small red spider from Texas was introduced and accomplished a little against the worst kind of prickly pear (*Opuntia inermis*), but later it seems to have come into conflict with even more useful agents. Thus the condition known as superparasitism arose.

Several different cochineals were employed, but these insects, though they established control of prickly pear in parts of India and Ceylon, made little impression on the worst species of the pest in Australia. Some of

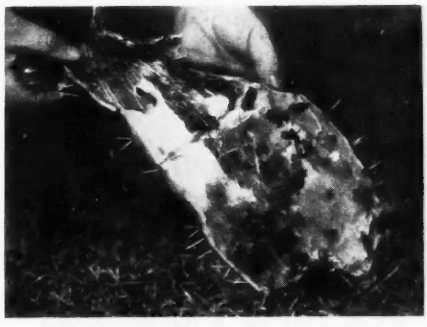
them proved to be exasperatingly particular about their food: for example, subspecies of *Dactylopius tomentosus*, obtained from the south-western U.S.A. and Mexico, though so similar that they could not be distinguished by experts, yet showed marked differences as to what kind of cactus they would eat, and sometimes they would eat one species and no other.

A plant bug (*Chelinidea tabulata*) from the same part of the world was brought in to help the fastidious cochineals, and a beetle (*Monoleima*) and some moths (or rather their caterpillars) called *Melitara* were also used. But none of these made any really substantial progress. Then, in 1924–5, *Cactoblastis cactorum* was rediscovered in South America. Specimens released in Queensland in 1926 showed great promise: in one subsequent period of twelve months 802,282,500 *Cactoblastis* eggs were distributed: by 1931 it was reported that the spread of prickly pear had been stopped and that the pest was being destroyed at the rate of 1,000,000 acres a year.

* * * *

This triumph was not achieved without great trouble. All the insects were tried for selectivity before export from America and again on arrival in Australia, where stringent starvation tests were imposed: for some species, at least, the method was to confine fifty specimens with sixty different kinds of Australian flora. These fifty specimens, by preferring to die rather than eat any of the "possible" foods, would prove that their kind could safely be released. In the U.S.A. alone there are at least seventy different insects which attack cactus, but several which seemed promising failed to pass this severe test.

Uncertain weather and the difference in the seasons—this last is liable to be an important factor when insects are being taken from the northern to the southern hemisphere or vice versa—complicated the work, and there was also the necessity of ensuring that any useful introduced insects were not affected by hyperparasitism; that is, that they did not bring with them parasites which would prevent their increase. Again, *Cactoblastis*, once established, was attacked by both disease and by a native ladybird (*Cryptolaemus montrouzieri*), but happily the caterpillar survived. Of course, several of the problems here mentioned and many others also arise with every experiment in biological control. For example, *Cactoblastis* has since been introduced into South Africa to control prickly pear, but there baboons have interfered, for they have found that cactus infested with juicy caterpillars has an agreeable taste!



Cactoblastis *at work on a pear leaf*

The insect pests which have been controlled with other insects are too numerous to be catalogued here, but a few may be mentioned, to show in how many different parts of the world this branch of applied entomology has proved valuable.

First, however, it should perhaps be noted that, when an insect pest is the enemy, the rigorous starvation tests which are essential before a phytophagous insect can be safely imported (to tackle a plant pest) are not necessary. Though insects required to control other insects must not be too fierce or too promiscuous in their tastes or they will be liable to run amok among beneficial indigenous species, it is often desirable that they should be willing to live on more than one prey or host. For example: When parasites were needed to

check the spread of the white spruce sawfly in eastern Canada, entomologists found that certain useful species could be more cheaply obtained from an allied pest, the pine sawfly. Obviously these parasites would have been useless for the required purpose if they had not been willing to transfer their attentions from the pine sawfly to the spruce sawfly. Again, when the western wheat-stem sawfly of America moved from indigenous wild grasses, where it was controlled by native parasites, to wheat, where these parasites could not reach it, the parasites of an allied but not identical English pest were introduced—an effort which would have been vain had the English parasites refused to live on the American host, the western wheat-stem sawfly. Such examples could be multiplied.

In America, the European corn-borer has been deliberately parasitized; several sawflies other than the two already indicated have been similarly tackled; the oriental fruit moth, the gypsy moth, the satin moth, the pine or balsam chermes, the citrus blackfly, the Japanese beetle, the sugar-cane moth, and indigenous grasshoppers are among other pests which have been the objects of biological control experiments in the United States. In British Columbia, the hawthorn scale, which was accidentally introduced thirty-five years ago and later became a serious pest, was practically exterminated in a few years by a parasite reared at Farnham Royal and shipped thence, "in cold storage, in glass tubes, with raisins as food"! In the same province the holly-leaf miner—another pest of English origin—is likewise being fought with parasites sent from this country.

The sugar plantations of Hawaii have been freed not only of the lantana already mentioned but also of leaf-hoppers, by measures of biological control. In Fiji, the coconut moth which interfered with the production of copra was tackled with parasites introduced from the Dutch East Indies. The control of plant pests in New Zealand has already been noticed: in the same country campaigns against insect pests have been successfully waged. A quarter of a million eggs of a small ichneumon fly were once imported from England for the parasitization of earwigs, and a few years ago a cabbage white butterfly plague was reduced in three seasons to comparative insignificance by parasites despatched from this country.

Various successful applications of biological control in Australia have already been mentioned, but here again insect pests have been tackled on the same lines. In Queensland, for example, pests of the banana and sugar-cane plantations have been fought with parasites and predators, and in the same state a small wasp has done good work against the woolly aphis of the apple. (This wasp was tried against the same pest in England, but unfortunately the experiments did not fulfil the promise, probably because of our climate.) A small flea which has done grave damage to Australian clover crops is now being tackled with mites, bred in insectaries; "glow worms", which are of course beetles, have been imported from England to deal with snails; and ichneumon were sent to New South Wales to parasitize the blowflies which lay their eggs in the nostrils of sheep.

Codling moth and the previously noted prickly pear plant are among the pests which are being fought with insects in South Africa, and scale pests of the coffee plantations father north (in East Africa) have been attacked with wasps. So the story goes on: even in the little Seychelles coconut scales have been biologically controlled, and ladybirds bred in England have been sent to the island of Montserrat in the West Indies to feed on citrophilous mealybugs there. Incidentally, the species of ladybird used was the same Australian *Cryptolaemus montrouzieri* which, in a wild state, made itself a nuisance by attacking specially introduced cactophagous insects. This ladybird has proved its value as a controller of mealybugs in California.

Two or three interesting experiments in the control of insect pests with creatures

other than insects deserve mention. In Puerto Rico, Hawaii, Queensland and Mauritius giant toads have been successfully employed against a pest of the sugar plantations. Last year, some of the imported toads unfortunately misbehaved themselves in Queensland: attracted (it was suggested) by the lights of a town, they left the plantations and invaded the streets.

Certain fish, about two inches long, have been exported from North America to Italy, Spain, Russia and India to control mosquitoes, which are specially execrated for spreading malaria. Last year the Government of Madagascar sent by air a present of some hundreds of fresh-water crayfish to the Government of Nyasaland. In parts of East Africa, bilharzia and dysentery are serious ailments, but Madagascar is known to be relatively immune: investigations showed that the Madagascan crayfish, by feeding on certain water snails, interrupted the life cycle of the fluke worm and amoeba which cause the two diseases.

It will perhaps have been noticed that practically all the biological control campaigns so far mentioned have been conducted abroad. This method of fighting pests has, however, been employed in Britain also. More than ten years ago Dr Speyer discovered that the greenhouse whitefly, the bane of tomato plants, could be controlled by a wasp-like insect from Asia, and this insect (*Encarsia formosa*) is now bred and used in large quantities in this country. Pine sawflies have been deliberately infected with parasites in both England and Scotland, and there are hopes that certain other pests (the pine beetle, for instance) will be controlled.

Two points have to be remembered in this connexion. First, research is expensive and the Treasury is not too generous in the allotment it makes for this work: for entomology is not a popular subject upon which elections are fought. (The Imperial Institute of Entomology, of which the famous Farnham House parasite laboratories are a part, is what its name implies: that is, the Dominions contribute to its upkeep.) Secondly, though there are notable exceptions, such as the western wheat-stem sawfly, and it is expected that in time such exceptions will become more numerous, most biological control victories have been scored against imported rather than indigenous pests. Clearly, it is both simpler and more obvious to control biologically an imported pest, and some countries have plenty of incentive for developing such work: for instance, of the seventy-three most serious pests in the U.S.A., more than half have been imported. Britain has distinguished herself as an exporter rather than an importer of controllable pests, and many parasites have been obtained in this country for control purposes abroad, while lack of funds has militated against research

An area densely infested by prickly pear

The same spot, 2 years later, cleared by Cactoblastis

into the more complicated problems of tackling our own pests.

It is also well to remember that success can never be guaranteed, and that parasites and predators which succeed in controlling pests abroad would not necessarily be equally satisfactory here. That point has already been illustrated by the woolly aphis problem in Queensland and in England. Another illustration may be found in ragwort, which has of late years spread so widely in Britain. The achievements of ragwort seedflies and cinnabar caterpillars in New Zealand are no proof that these insects would succeed here. For instance, before tackling English ragwort with cinnabar caterpillars, an entomologist would immediately ask, why this insect, which is indigenous to England, has failed to control the ragwort of its own accord, and he would wish to find out why cinnabar caterpillars have become rare, and whether the factors which have presumably worked against them have now ceased to be active.

It will thus be seen that, although biological control has great possibilities in many parts of the world, the method is not applicable to every pest in all conditions. There are innumerable complications to be considered and, if there is to be any good hope of success, every campaign must be preceded by thorough research and be conducted with that caution which is the very essence of true science.

Sigmund Freud

1856–1939

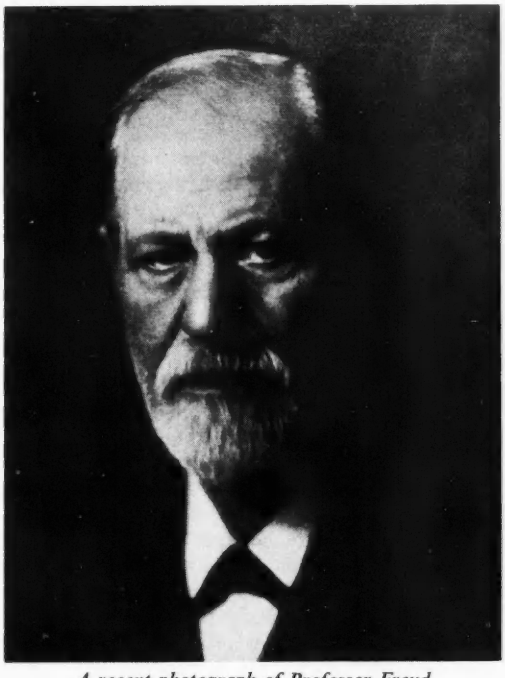
An Appreciation by H. Banister

It is difficult to assess accurately the work of a great man who stands close to us in time, still more difficult to gauge the position he will take in history. Theories come and go, and the thoughts of man, widening with the process of the suns, find the theories of a fresh generation utterly inadequate to subsume the truth as it is apprehended to-day. Nevertheless, when we consider the volume and extent of Freud's work, the vigour of its impact on contemporary psychology, the fundamental changes in outlook which it has wrought, and the amount of human suffering which its applications have alleviated, it seems impossible to deny to Freud a position in the history of the science of the mind comparable with that of Lavoisier in chemistry, of Newton and of Rutherford in physics, and of Darwin in biology.

Indeed, it is of Darwin that one inevitably thinks when the work of Freud is compared with that of his peers in other branches of science. For Freud was no maker of theories based on a flimsy foundation of hastily collected facts. He was, like Darwin, an incomparably skilled and cautious observer, one who collected facts on an immense scale, objectively minded in a realm where objectivity is supremely difficult to attain. Moreover, Freud's work had to encounter a sustained resistance, which in its volume (and in its singular lack of comprehension of the essential nature of the Freudian thesis) has had no parallel since the publication of the *Origin of Species* and the *Descent of Man*.

Born of Jewish parents at Freiburg, a small town in Moravia, on 6 May 1856, Sigmund Freud went as a child of four with them to Vienna, where at the Gymnasium

he was always at the top of his class. His father insisted that, though the family circumstances were poor, Sigmund should follow his own inclinations in the choice of a profession, and thus it came about that, as a result of hearing Goethe's essay on Nature read aloud just before he left school, he decided to become a medical student, though neither then nor later in life did he feel any strong predilection for the career of a physician. In 1873, at the age of seventeen, he went to the University where, as a Jew, he found himself in an uncongenial atmosphere. For some years, from 1876 to 1882, he worked in the physiological laboratory under Brücke on problems connected with the histology of the nervous system, his medical studies being somewhat relegated to the background, so that it was not till 1881 that he qualified. For financial reasons he left the laboratory in the following year and took a post in the principal hospital in Vienna where he continued his researches, especially on the medulla, and became an active worker in the Institute of Cerebral Anatomy. He declined an offer to lecture on the anatomy of the brain and began the study of organic nervous diseases, in which branch of medicine there were at that time but few specialists in Vienna. His clinical observations upon organic diseases of the nervous system began to attract attention and, as a result, in 1885 he was appointed lecturer in neuropathology, and, being awarded a Travelling Fellowship, he journeyed to Paris to study under Charcot at the Salpêtrière. Here he was struck by the differences between hysterical and organic paralyses and anaesthesias, and, after discussing the question with Charcot, he decided, in spite of the strong disapproval of his colleagues, to study hysteria from the psychological point of view. In 1886 he settled down in Vienna as a specialist in nervous diseases and married. It is interesting to note that his future wife was the unwitting cause of his failure to discover the anaesthetic properties of cocaine. In 1884 he was studying the properties of cocaine, when an opportunity arose for him to visit his fiancée whom he had not seen for two years. He hastily stopped his investigations, but suggested to a friend, an ophthalmologist, that he should experiment with a view to using cocaine as a local anaesthetic. On his return to Vienna Freud found that in the meantime another friend, Koller, had carried out the experiments successfully. "But", Freud naïvely says, "I bore my *fiancée* no grudge for my neglected opportunity of making the discovery."



A recent photograph of Professor Freud

As a specialist in nervous diseases Freud found his interest in organic diseases waning, while the study of the hysterical cases and their treatment by hypnosis became ever more fascinating. In conse-

quence, in 1889 he journeyed to Nancy, where hypnotism was widely used, in order to perfect his technique by a study of the methods of Liébault and Bernheim. However, he found that the removal of symptoms by suggestion under hypnosis gave no lasting results, and set to work to find other methods of treatment. Some years previously, in 1884, Breuer had recounted to him the results of an investigation he had carried out between 1880 and 1882. A hysterical girl patient had been relieved of her symptoms after she had given free expression under hypnosis to the emotional experiences by which she was at the time dominated. In her waking state she could not describe how her symptoms had arisen and could discover no link between them and any other experiences. Under hypnosis she revealed the connexions.

Freud applied this same technique with marked success, and eventually persuaded Breuer to collaborate with him in the publication of their findings. The result was a book, *Studien über Hysterie*, which was published in 1895, after somewhat similar results obtained by Janet had been published; and the importance of unconscious factors in the causation of hysterical disabilities was proved beyond doubt. But the technique of hypnosis was difficult and often unsatisfactory. Freud then remembered that Bernheim, who maintained that memory was present all the time, had made his subjects recall, on awakening from a deep hypnotic sleep, the forgotten experiences which they had recalled under hypnosis, and determined to endeavour to obtain recall in the normal waking state without hypnosis, encouraging and assuring the patient who merely lay relaxed on a sofa. In this way the method of "free association" was evolved, and a new way was now open for a serious attack on the problems of the psychoneuroses. It was found that the forgotten, or unconscious, memories had always in some way or other been painful to the patient, and that they were, on final analysis, sexual in nature.

By patient observation and brilliant intuition Freud slowly built up his theories, modifying and changing his hypotheses as observation demanded. He made use of dreams and published his book on their interpretation in 1900. He stressed the importance of the unconscious owing to its dynamic influence on mental life. He showed that the mind consisted of separate parts, the separation being the result of contending forces; that "repression", the apparent forgetting of unpleasant experiences, was the result of such conflict; that the Œdipus complex, the outcome of the conflict aroused through the infantile sexual attitude to the parents, was not only the central factor in neurosis but also made a fundamental contribution to the formation of character. Extending his range he maintained that the same mechanisms were to be found in wit, literary work, art, mythology, in anthropology, education and religion.

For many years he worked alone, but in 1906 he was joined by other psychiatrists, and two years later the first International Congress of Psycho-Analysis met. In 1910 the International Association was formed with branches in many countries. Freud's teachings aroused great opposition—an opposition characterized by a wholly unscientific emotional bias. There was the opposition, still not wholly overcome, of many members of the medical profession who were unwilling to acknowledge that illness could be caused by non-physical means; of the philosophers who rejected the concept of unconscious mental activity; of the general populace, who objected to the importance assigned to sex. But these objections and execrations left him undisturbed. To him nothing mattered in comparison with scientific truth. From the time when he first encountered hostility at the University, through the period when, in spite of violent opposition, he calmly continued his study of hysteria, to the end he pursued a steady course. Friendship he sacrificed on the altar of truth—Breuer, Adler and Jung, to mention only three,

passed from his circle because they disagreed with what he thought was right.

Whatever value the future will ascribe to his psychological theories and to his labours in the clinic, there can be no doubt of the greatness of the man. Towards the end of his life honours came to him. He received the honorary degree of LL.D. from Clark University in 1909; on his seventieth birthday he received congratulations from learned societies in various parts of the world and the freedom of the city of Vienna; he was elected to foreign membership of the Royal Society in 1936. But it was a tragedy of his short residence in England after the *Anschluss* that it was found impossible to give him what he most ardently desired and would have valued above all other distinctions—the status of a British citizen.

Changing Flower Patterns by Artificial Means

By GABRIELLE RABEL

An account of some recent experiments which show that the colour patterns on the petals of flowers, such as petunia, calceolaria, and pansies, can be modified at the wish of the experimenter by careful controls of light and temperature while the flower is in bud.

WORK carried out by Professor Harder of the Botany Institute in Göttingen has shown that the patterns in certain flowers can, to an astounding degree, be changed by artificial means. Temperature is, as a rule, the active agent in the changing of patterns in such flowers as the pansy, maidenwort, calceolaria and calliopsis, but, in the petunia light plays an equally influential part.

Some brownish markings are caused by the red and blue dye, anthokyan, on a yellow ground, and it is an interesting fact that there are some flowers in which heat, by destroying the covering of anthokyan, makes the petals appear pure yellow (*Mimulus tigrinus*, *Calceolaria hybrida*), whereas there are others in which heat has the opposite effect, so that petals which are white or yellow under normal conditions turn dark in the hothouse. The behaviour of petunias is particularly interesting. When a dark flower whitens in a decreasing temperature, it does so, not by a gradual and uniform fading of the colour, but by the appearance of white stripes on the petals, in some cases spreading from the centre to the periphery, and in others from the periphery to the centre. These stripes increase in such a way that all grades between violet and pure white are represented (Figs. 1, 2).

The effect of light is opposite to that of heat. Strong light, like cold, is hostile to the pigment, while feeble light, like heat, favours it. By appropriate combination of light and temperature, any desired amount of spots or stripes can be produced. Professor Harder supposes that, as in other photochemical processes, the total quantity of light (time × intensity of illumination) required for a certain effect is constant, so that increase of one factor would allow reduction of the other.

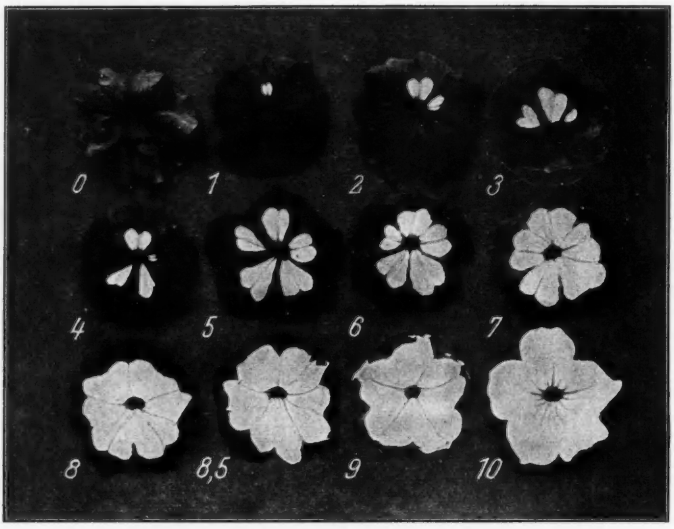


Fig. 1. Petunia hybrida grandiflora. "*Kriemhilde*"
Spots spreading centrifugally as temperature decreases from about 35° *to* 15° *C.*

After the flowers have opened, no external influence is able to alter their pattern. Their sensitive period is at a much earlier stage—up to a month before opening. That means that the flowers which open, say, 2 or 3 weeks after the experiment, still show their normal pattern, and only those appearing later reveal experimental influence. The sensitive stage, in petunias, covers the period when the buds grow from 1 to 2·5 mm. At 30 or 35° C. this period lasts only 2 days, but at 15 or 20° C. it extends over a week or more. As long as the sensitive stage lasts, every outward stimulus shows some effect on the plant, and, by changing conditions systematically and often during this period, complicated designs can be produced artificially. In *Calceolaria hybrida*, large and small spots can be made to appear side by side by twice changing the temperature (Fig. 3). There are some flowers which are white when they open, but become coloured very soon after. In the petunia, for example, the prestage of anthokyan, i.e. flavonol, can be ascertained by chemical methods in the uncoloured petal, while the parts which are to remain white keep definitely free from flavonol. But this distinction cannot be made before the petal has a length of 4 mm., which means that, during the sensitive period neither anthokyan nor flavonol is being formed. And yet this period is decisive for the latter distribution of the pigment. On the other hand, it is not decisive for the intensity of the pigmentation. This appears to depend upon the conditions prevailing while the flower is opening to the light.

Some sorts of pansies show very striking changes in the hothouse (Fig. 4), but the three characteristic spots which form the "face" of the flower have proved absolutely resistant to all influence. The lower lip of *Lamium* and the orchid *Ochrys* showed themselves to be equally resistant to all attempts to change their patterns.

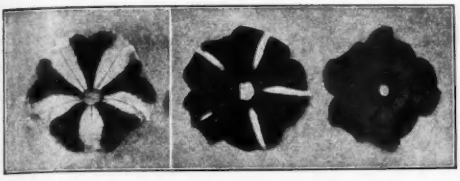


Fig. 2. Petunia nana multiflora
Centripetal progression of stripes

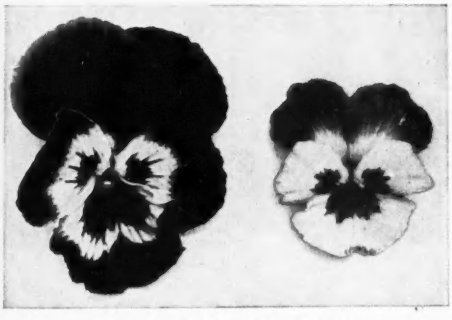


Fig. 4*a*. Viola "*Nordlicht*"
Left, in open land; right, after culture at 30° *C.*

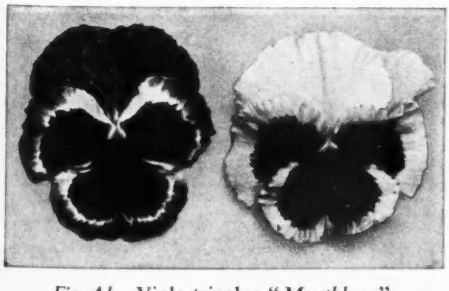


Fig. 4*b*. Viola tricolor "*Montblanc*"
Left, in open land; right, after culture at 30° *C.*

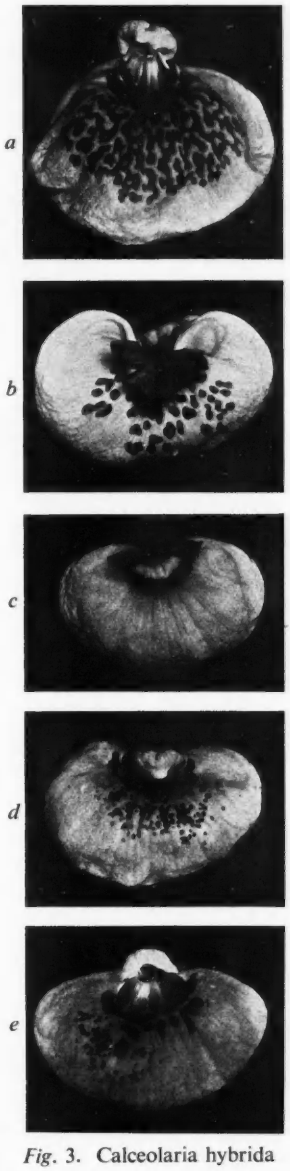


Fig. 3. Calceolaria hybrida

a	*temperature constantly low*	
b	,,	*first low then high*
c	,,	*constantly high*
d	,,	*first high then low*
e	,,	*first low then high and again low*

SOME ENGLISH TOADSTOOLS

Photographed by Reginald Harrison

Because they are flowerless, toadstools receive less attention and suffer more destruction than they deserve. There are no fewer than four thousand species in England. Although a few are parasites on living wood, the majority perform the useful duties of scavengers to nature, consuming masses of the dead and decaying matter which abounds everywhere. A few are decidedly poisonous to human beings although slugs and flies feed on them with impunity. Many are edible, far more tasty than the mushroom, and much appreciated on the Continent. They well reward the study and attention of more amateur field naturalists, and many of them have forms and colours which are undeniably beautiful, particularly in their autumn settings.

Pillar puff-balls, a species of *Lycoperdon*

The Parasol Mushroom, *Lepiota procera*

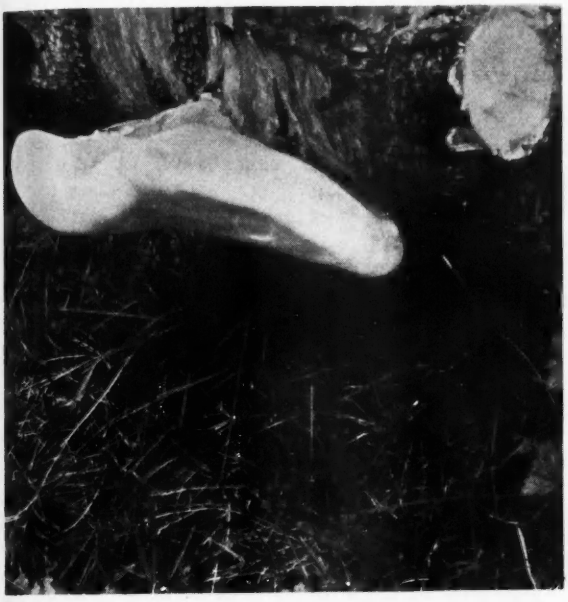
In parks, orchards, and sometimes among the bracken may be found a very large toadstool with a brown, scaly cap often measuring a foot across. This is the parasol, and the long, upright stem and the loose ring attached make identification easy. It can be cooked in the manner of mushrooms.

The Honey-coloured toadstool is found in dense clumps, it is a parasite, and the trees near which it grows are often sickly or dying. The bark of its victim, too, is usually loose, and on removal the network of "roots" will be discovered. Acrid taste, edible.

Honey-coloured toadstool, *Armillaria mellea*

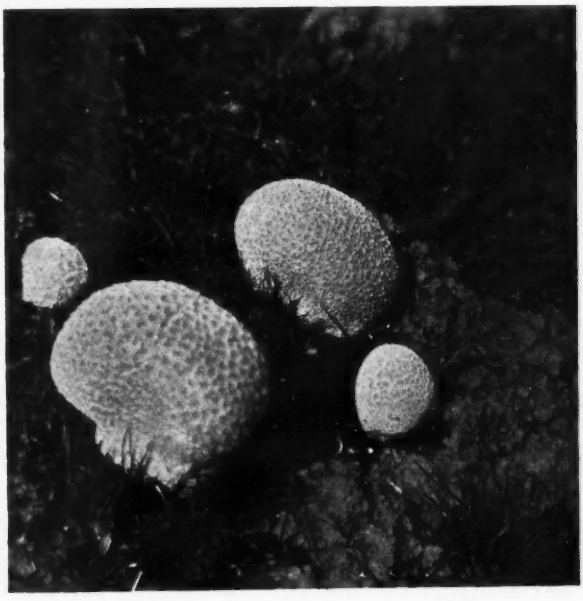
The Lawyer's Wig or Maned Ink-cap, *Coprinus comatus*, may be found in woods, pastures, or by the road side. It varies in length from 4 to 15 cm., and its cylindrical disc is silky and shining. It is one of the edible toadstools, and has a mild taste.

Fly agaric, *Amanita muscaria*, is the brilliant scarlet, white-flecked toadstool so often found in association with birch trees and bracken. Highly poisonous, its juices were once used in the manufacture of flypapers.



The Polypore,
Polyporus betulinus

Birch trees are the host of the polypore, a bracket-like fungus which is easily seen. This is one of the parasites which dooms the living tree to slow destruction. The visible part of any fungus is really the "fruit", and the roots extend sometimes for many yards either in the tree-trunk or underground, thus making it difficult if not impossible to exterminate before the damage is done.



Sculptured puff-balls,
a species of *Scleroderma*

Puff balls form a large group of their own, and range from the giant, found in pine woods and often two feet in diameter, to the tiny white kinds of the fields. Each puff-ball on ripening contains untold millions of spores, which are carried away by the wind.

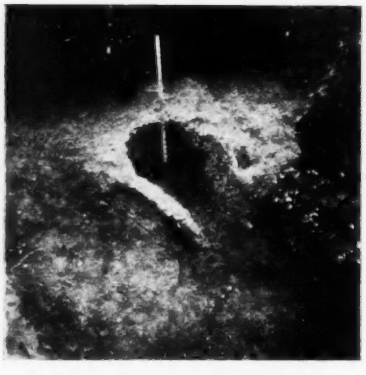
Discovery of a Pre-Roman Well at Ewell, Surrey

By S. G. Nash

An excavation has recently been temporarily completed at a site in Ewell, Surrey, and has proved of unique interest in at least two features. Originally discovered by chance during the course of excavation for a block of flats on the site of a demolished house known as Purberry Shot, work was commenced on a scientific basis at the beginning of the spring, and continued until June.

A local inhabitant, interested in archaeology, first remarked that there was definite evidence of the section of a road uncovered about 18 in. below the surface. Permission was given to cut a complete section of this road which proved to be of late second-century date, not heavily metalled and therefore obviously not a military road, constructed of flints and chalk blocks overlain with pebbles and grit. At two places within the section ditches were found, a feature that has now been recognized as characteristic of Roman roads, in addition to the usual ditches at the sides of the road. When the section was completed it was noticed that the road material dropped considerably at one edge, and excavation for the purpose of discovering the reason for it showed disturbed earth at this point. By the time a depth of 10 ft. had been reached it was realized that either a well or a mine had been rediscovered. Eventually a depth of 42 ft. was attained, with evidences, by probing, that a further 3½ ft. remained. By this time, however, water-level had been touched, and further work became impossible.

The filling contained much Roman and Early Iron Age "A" pottery. This occupation prior to the Romans is substantiated by trial trenches taken elsewhere at the same time, leading to the discovery of (1) the floor of a hut, made of pebbles closely packed, (2) considerable quantities of nails, but no building material, evidencing timber erections only, (3) a kiln, either for smelting metal or firing pottery, (4) many pieces of pottery of Early Iron Age "A" type.



A view of the kiln from the front

The kiln from the side

A considerable quantity of "clinker" or iron slag was also found, over the whole site, and lends support to the theory that it was a primitive iron-works, a settlement in existence at the time of the arrival of the Romans. A piece of Roman chain-mail, found in the neighbourhood about thirty years ago, is therefore given a new interest by these present finds.

The Romans, in their ruthless adherence to the straight road principle, found it necessary to fill in the well, which is, therefore, pre-Roman in construction. Herein lies one of the features that gives the site unique interest; that it is the earliest known well in Britain.

The pebble floor of the hut dwelling

The same floor, shown in greater detail

The second is a find made in the filling—a razor, this being the only Roman razor discovered in Britain.

The finds represent uninterrupted occupation from the Early Iron Age "A" of 300 B.C. to late Roman times. The period 100 B.C. to A.D. 45 is, as a matter of fact, poorly represented, but it includes some pieces of decorated ware which are of considerable value for the study of the later pre-Roman period and the diffusion of what has been termed "Eastern B" pottery.

The newly discovered Roman road runs in the direction of Stane Street, which, by alignment, it would reach in about a quarter of a mile. Whether it ends at the settlement or continues is a question the future may solve. But at least it is a proof—if proof were needed, after a series of unexpected discoveries extending over thirty years—of the importance of the site in Roman times of the village where contemporary Ewell stands.

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The Speed of Birds, by H. T. Winter

(Founder Member of the Royal Aeronautical Society)

MANY birds have been credited with marvellous flying speeds and 200 miles an hour is often mentioned as being attained by the swift and the swallow; but such accounts must be considered rather as flights of fancy than of fact.

While recently engaged upon aeronautical research I found it advisable to obtain figures of the performance of birds in flight. The verification of these performance figures proved once again how very difficult it is to acquire exact knowledge. Lack of information on two points makes it difficult. When naturalist observers give the results of their investigations it is most rare to find any statement as to the method of measurement employed (if any), or any account of the meteorological conditions prevailing at the time of the observations.

There seems to be a great temptation for observers to allow their enthusiasm to override the need for accurate observation reinforced by instrumental aid. Once this is realized we are bound to set aside speeds of 200 m.p.h., and miraculous flights such as that which credits the migrating turtle dove with leaving the Kentish coast at dawn and in an hour or two coming to earth in Portugal.

Some naturalists have held that the speed of level flight is greatest during migration. Apparently this view owes something to the idea that these long flights are made at high altitudes where more uniform conditions and lower air resistance are conducive to better performance. There is no evidence to show that migration is carried on at very great heights, indeed it would be surprising if it were. For such long flights it is essential that the bird's energy should be conserved as much as possible, yet high altitudes would make great demands upon the physical condition of the flyer. Shortage of oxygen would put an undue strain upon the heart and lungs, while the lower density of the air would demand a much greater effort from the wing muscles to produce a reaction equal to that normally required for flight at lower levels.

For these reasons alone it appears that migration is performed at normal flight speeds, that is, the usual speed of level flight of the particular species under consideration. It is necessary to stress the term normal level flight, for all birds have another speed of flight which may be called the pursuit speed, since it is a higher speed than normal, employed when the bird is either pursuing its prey or attempting to escape from an enemy.

There is yet another flight speed. Just as a diving bomber may reach extremely high speeds for a short time so does a bird of prey like the falcon when swooping down upon its quarry appear to travel at a speed in the neighbourhood of 100 m.p.h. The measurement of the speed of such a dive is most difficult and the results are open to doubt.

Level flight speeds are measured in several ways, most of which depend upon observations from some fast-moving vehicle travelling in the direction of the flight. A great number of observations have been made from motor cars, and the bird's speed is found from the car's speedometer reading. Quite a large number of flight speeds have been measured from machines of the Royal Air Force, and the results should be particularly valuable since both bird and aeroplane are subject to the effects of the same wind.

Another series of important measurements has been obtained by the use of theodolites. A pair of observers at the opposite ends of a measured base-line are in telephonic communication and by the aid of stop-watches record the speed of flight.

For a number of years research in this interesting subject has been carried out in many parts of the world, and recently an official of the United States Department of Agriculture has made a report on bird flight in North America. The results, for birds of the same species, are very similar to those obtained in Europe.

Which is the fastest bird? Nine people out of ten would give the swift or the swallow as the feathered speed record holder, yet the search for trustworthy evidence in support of remarkable performances of these flyers does not yield very satisfactory results. Col. R. Meinhertzhagen, the ornithological expert, refers in *Ibis* to the report of a flight of a swallow from Roubaix to Paris, a distance of 160 miles, as having been performed in 90 minutes. This gives a speed of 106 m.p.h. The authenticity of this "record" he holds to be distinctly dubious. The same authority is still more sceptical of a curlew "record" of over 4 miles per minute, which is mentioned by Gätke.

As far as is known the lammergeier holds the speed record for diving flight. One of these birds while swooping down to escape from an aeroplane in Italy was found to be travelling at 110 m.p.h. Another of the same species, gliding at an angle of descent of 12° reached 79 m.p.h.

The R.A.F. reports a flight speed of 68 m.p.h. by a swift. Assisted by a favourable wind a homing pigeon flew from Banff to Hampshire, a distance of 500 miles, at a speed of 62 m.p.h. A golden plover in England, when chased by an aeroplane, flew at 60 m.p.h. This speed was measured by the aeroplane's air-speed indicator.

These speeds are all very high, for there are few occasions when any bird flies at 60 m.p.h. The average level flying speed of the majority of birds is much nearer 35 m.p.h. Some careful flight tests that were carried out in India bear this out. Two theodolites were employed at both ends of a base-line of 1200 ft. On a day with no wind a swallow flew at a speed of $37\frac{3}{4}$ m.p.h. On another occasion when there was a fairly strong head wind the swallow's speed was 34 m.p.h.

Among other interesting observations by the R.A.F. may be mentioned a speed of 57 m.p.h. by a quail, 48 m.p.h. for a gannet and 40 m.p.h. for a pheasant.

A number of features emerge from the American report which are worth recording. In the first place the average level flying speed of those birds which have been observed appears to be about 30 m.p.h., a

result which supports the European observations in placing this figure at well under 50 m.p.h. From the analogy of the aeroplane it might well be thought that the highest speed would be attained when the bird is favoured by a tail wind, but this is not the case, for the greatest speeds are attained with a side wind. This is a remarkable fact. It may well be that the science and art of aviation would profit from the results of further research into the causes of this paradoxical phenomenon.

Of all the birds that were under observation in the United States rarely were any seen at a height above 3000 ft. and none above 5000 ft. Possibly the altitude record of the feathered world is held by the lammergeier or bearded vulture. This great Palaearctic bird, which has a wing span of 46 in., has been seen flying in the neighbourhood of Mt Everest at the remarkable height of 24,000 ft. or 4·55 miles. Thus both for speed and altitude the lammergeier occupies a unique position among birds.

Much remains to be known about bird flight, and it is certain that further study of the effect of meteorological conditions on performance would be of value. It is interesting to note that roughness in the air affects some birds far more than others, quite apart from the mere matter of size and strength. For example, in one case it was seen that turbulent conditions had no discernible effect upon a flock of geese, whilst the flight of crows was so adversely affected that they were unable to return to their nests.

Possibly the most remarkable features of bird flight are associated with the performance of the great soaring birds. Some of these birds, which weigh as much as 30 lb. and have a wing area of some 7 sq. ft., are able to soar to great heights without flapping their wings. These astounding results are achieved by a flying technique requiring an almost unbelievable degree of skill. Soaring birds possess an instinctive knowledge of the properties of moving air masses which enables them to climb by two different methods. The more obvious method is to glide into rising air currents and ascend with the upward stream. Such upflowing currents are to be found wherever wind blows over rising ground, especially, for example, where a sea wind comes ashore over a cliff face. Then there are the thermals or currents directly caused by differences of temperature of the earth's surface in more or less nearby localities. The presence of cumulus cloud usually indicates the existence of a thermal up current both in and beneath it.

A less obvious way of gaining height without wing flapping is the employment of variations in the strength of the wind. Over land especially winds are almost always gusty, and it is the energy derivable from these gusts that the soaring bird employs.

It is difficult to say which of the soarers is most skilful, but among land birds the vulture and the kite rank high, while of sea birds the great albatross holds the palm.

A record of quite a different kind is held by the humming bird. The writer was recently privileged to see a delightful film of this daintiest of birds. One series of pictures showed one bird on the wing while drinking from a small glass vessel. It was fascinating to watch the little creature remaining poised in the air with just its beak in the liquid. This film was made possible only by the aid of a new type of camera with a shutter speed of 1/100,000th of a second. Thus for the first time it was possible both to count the wing beats and examine the nature of the wing movements. Incredible as it may appear the wings of the humming bird flap at the rate of 200 beats *per second*.

The endurance record surely goes to the golden plover, one species of which migrates from its breeding ground in Alaska to the islands of the Low Archipelago in latitude 20° south. This journey, performed each winter, involves at the lowest computation an oversea flight of 3000 miles.

The Early History of the Microscope

By Hilda Herne

"Who, a thousand years ago, would have imagined it possible to distinguish Myriads of living creatures in a single drop of water...?"

So wrote Henry Baker, Fellow of the Royal Society and Member of the Society of Antiquaries in London, in the introduction to his book *The Microscope Made Easy*, printed for R. Dodsley in 1743. And he continues: "To what Accident, to what country, or to whom we are obliged for the Invention of Microscopes is not in me to determine, the Honour has been given by some to Drebbel, a Dutchman, by others to Fontana, a Neapolitan, and by others still to different people. The first appearance of them, however, was about the year 1621, since when they have been improving down to the present time."

It is, indeed, curious that the development of the microscope should have been so slow.

We have to go back to earliest antiquity for what is probably the oldest magnifying glass. It is of rock crystal (roughly circular, about $1\frac{1}{2}$ inches across and $\frac{1}{3}$ inch thick), and was found by Layard in the ruins of Nineveh. Lenses, however, were known to the ancients. We find them mentioned by Pliny (*Hist. Nat.* Bk. 37, Chap. 12) and by Seneca (*Quaestiones naturales*, Bk. 1, Chaps. 3, 6, 7). They were generally of crystal or glass, but all sorts of other substances were tried, e.g. transparent minerals, even jewels, pebbles, glue, oil, resin and water. At first they were probably adopted as temporary aids to sight as portable magnifying glasses. Probably the primitive nature of the available material was the chief reason for the delay in further developing the original invention. Centuries seem to have passed before anyone definitely laid down the principle of magnifying small objects. One Arab writer of the eleventh century refers fairly clearly to the conditions under which, by the aid of a convex lens, an object may be magnified (Alhazen Ibn al Haitan, *d.* A.D. 1052). Roger Bacon was also aware of the phenomenon, though whether he was able to construct an apparatus which may have been the ancestor of the microscope we cannot tell. It is true that eye-glasses were being constructed in the thirteenth century, but still the difficulties of grinding, preparing the lenses and adjusting them in an instrument, proved insurmountable.

By the sixteenth century many scientists appear to have been on the verge of the discovery. Giambattista Porta, in his *Magia Universalis*, writes of lenses, "he who can find out how to assemble them correctly will have discovered no small secret...if you can fit them together properly, you will be able to see objects both distant and near, much larger and much more clearly".

Galileo's Microscope

The great Galileo, who had been patiently working on his telescope, was informed by a friend in Paris that a certain Belgian had invented a machine for magnifying small objects. Following the description provided, Galileo at once began to work on the same problem. He certainly made an instrument approaching the modern field-glass, for we read in Priuli's chronicle (1609) that Galileo took him and

several friends to the top of the campanile in Venice and showed them the various buildings of the city greatly enlarged.

Who was the Inventor?

In spite of the tremendous scientific activity at that time and the great amount of correspondence between one worker and another, which we actually have, no one has been able to establish with absolute sureness who was the actual inventor of the first microscope. It may have been the Dutch (Belgian) worker reported to Galileo, it may have been Galileo himself, who put the few remaining touches to his "occhiale" to transform it into the "occhialino" as early as 1609. Jean du Pont de Tarde, a canon of Sarlat, went to Florence to see Galileo on 11 November 1614 during the latter's illness, and he says that Galileo gave him full instructions how to "see little objects greatly magnified". On the other hand, Galileo's great friend, Fabri de Pieresc (1580–1637), a remarkable man, who, aided by his great wealth, was able to keep in touch with every department of scientific progress, does not seem to have known about Galileo's first suggestions for his "occhialino" which was evidently a microscope with a convex objective and concave ocularii. De Pieresc was for a quarter of a century the initiator of all the foremost ideas and kept up a continuous correspondence with scientists in every country, besides maintaining a number of investigators who travelled from place to place. He first mentions Galileo's instrument in 1620, and Galileo himself wrote to Prince Cesi in 1624 telling him that he had an "occhialino" to magnify small objects.

The practical difficulties were so great that it is most probable that several workers reached the same point of perfection at approximately the same time. Zaccharias Jannsen, a famous optician working at Middelburg in Holland, was certainly producing some ingenious instruments, and it may have been to him that we owe the microscope. Anyhow, we have one piece of testimony to this effect, which, though not contemporary in date, is couched in explicit language. On 9 July 1655, Petrus Borellus, physician to Louis XIV of France, received a letter from William Borel, Belgian ambassador; a translation from the Latin, of one passage, is given here:

"This Hans, i.e. John, a certain spectacle maker, with his son Zachary, were, as I have several times heard, the first to invent the microscope. They offered it to Prince Maurice, the Governor and Commander-in-chief of the Federated Belgian Army, and received a present of money in return. Later, microscopes similar to this were presented by them to the Archduke Albert of Austria, Supreme Governor of the Kingdom of Belgium. When I was ambassador in England in the year 1619, Cornelius Drebel, a Dutchman from Alckmar and a man acquainted with many secrets of nature, who was in the service of King James as mathematician and well known to me, showed me this microscope which the Duke himself had given him, namely, that of Zachary. It did not have a short tube, as those now shown, but its tube was about 6 ft. long, of gilded brass, 2 fingers width in diameter. It stood supported by three brazen dolphins on a pedestal of ebony. We were able to see, very greatly enlarged, a number of small objects placed on the pedestal."

Fontana, a Neapolitan lens and instrument maker, describes in 1646 his "parvum specillum", which was his name for his microscope, in contrast to the "tubus opticus astronomicus" or telescope. The word microscope was not regularly used until later.

Descartes' "Megaloscope"

Descartes, in his *Dioptrice et Meteora* (1637) describes two microscopes of his own. The first was a small instrument consisting of a lens (not much larger than the human eye) fitted with a reflecting mirror and an attachment to hold the object under observation—which was examined against the light. The second was

what Descartes called his "megaloscope" and is probably an ideal construction never actually carried out. The principle is the same, but the instrument is much larger, supported on a stand and somewhat similar to a telescope in design. The object was placed before the lens and also viewed against the descending light.

Leeuwenhoek and his twenty-six microscopes

One of the greatest users of the microscope at this time was Leeuwenhoek, a remarkable man, self-taught, indefatigable in research, who examined everything that came within his reach. He made his own microscopes (which consisted of simple, not compound lenses). The following account is by William Molyneux in his *Dioptrica Nova* (London, 1692): "The Heer Leeuwenhoek of Delft in Holland has lately applyd himself with great Diligence to the use of Microscopes: of which Instrument he thinks he has a better kind than was ever yet known. When I visited this Gentleman at Delft, he shew'd me several that indeed were very curious, but nothing more than what I had ordinarily seen before; being composed of one single very minute Glass-Sphere or Hemisphere, placed between two very thin pierced Laminae or Plates of Brass, and the Object was broaght to its due distance before the glass by a fine Screw, but for his best sort, he beg'd our Excuse in concealing them."(!) Henry Baker had the opportunity of examining several of Leeuwenhoek's microscopes very carefully, and his account is more exact:

"The famous microscopes of Mr Leeuwenhoek are the most simple possible, being only a single lens set between two plates of silver perforated with a small hole, with a moveable pin before it to place the object on and adjust it to the eye of the beholder.... The cabinet of microscopes left by this famous man, at his death, to the Royal Society as a legacy, is standing upon my table... every one of the 26 microscopes contained therein is a double convex lens ...and not a sphere or globule."

The magnifying power of these microscopes was 40–72 times (in the case of nine), 80 times (eight), 100–133 times (five) and 160 times (one only).

During the first half of the seventeenth century a number of works were published containing observations on natural history with drawings which could only have been made by the aid of a magnifying apparatus. Bacteria were observed for the first time (although they were called "animalculae"), and the wonders of minute life began to be slowly revealed. Count Carlo Manzini, an Italian mathematician and astronomer, author of *L' Occhiale all' Occhio* (Bologna, 1660), containing a description of Galileo's instrument and also several chapters on the making of lenses, speaks of the microscope revealing marvellous creatures "living in vinegar, tiny worms twirling in milk and in the blood of fever patients, and an infinity of living animals in cheese...."

Other workers continued to elaborate the simple microscope. Nicolas Hartsoeker, a very able Dutch microscopist, when only eighteen, submitted to the French Academy a microscope by the aid of which he had distinguished the spermatozoa, and later he succeeded in inflaming the jealousy of Leeuwenhoek.

The Compound Microscope

But the double or compound microscope soon proved of wider application. In England, John Marshall produced an instrument through which one could observe the blood circulation in the tail of a little fish. Marshall's microscopes were large, consisting of a tube about 15 inches long. His contemporary in France, Joblot, brought out a "petite machine nouvelle", an elegant little microscope which he provided with a cover, knob and pedestal "pour luy donner plus de grâce", as he charmingly says. We do not mean, however, to disparage Joblot's achievements. He produced many valuable microscopes

and published a book, *Descriptions et usages de plusieurs microscopes nouveaux* (Paris, 1718), with many interesting drawings of instruments and of substances viewed through his latest pattern microscope. (This book was translated by George Adams and appended to his *Micrographia Illustrata*, 1747.)

In 1672 Isaac Newton communicated to the Royal Society a description and drawing of a reflecting microscope which seems to have been the first of this type actually constructed. This idea was similar to that of Descartes.

Throughout all this early period it is well not to forget the debt we owe to the great learned societies which date from this time. The famous Accademia dei Lincei founded by Prince Cesi in 1603 united the greatest Italian scientists. Prince Cesi himself was an ardent student of the microscope. He had instruments made according to the latest designs and these he offered to those scientists he felt to be capable of making profitable use of them. In Paris, the Académie des Sciences, and in London, the Royal Society, provided opportunities for the dissemination of the latest ideas in all departments of science. The enthusiasm grew to such proportions that every scientist, every amateur and every man who wished to be considered cultivated as befitting his rank or position, had his own microscope. Louis XV of France, wishing to make his father-in-law, Stanislas of Poland, a suitable gift, ordered a microscope of the most recent invention from Magny, that "artiste habile et éclairé", who was one of the best instrument makers of the time.

The early difficulties had now been overcome. Technical progress in lens preparation, in methods of measurement and calculation, better materials, the adoption of reflecting mirrors, of condensers, etc., and finally the invention of achromatic lenses, had gradually dispelled the romantic atmosphere of the early years of discovery, and left the way absolutely clear to the modern worker.

Emulsions in Industry

(*Emulsions, that is the physical mixture of two liquids which will not normally mix, have many domestic, industrial, and medical uses. The principle of emulsification and the action of emulsifying agents is described briefly in this article, which will be of interest to those readers who remember the article on The Science of Washing in the June number of* Discovery.)

THE word Emulsion probably calls to mind the familiar Cod Liver Oil Emulsion, but emulsions are actually in very much wider use, and such things as butter, milk, sauces, toilet creams and shoe polishes, are usually emulsions. Though the scientific aspect of emulsions has been intensively studied, yet there are still problems awaiting solution, and the subject is one of never ending fascination, and almost every day sees the patenting of a new emulsifying agent or a new use for emulsions.

An emulsion, technically, is a system of two liquids, which normally do not mix, disposed in such a manner that one liquid is broken up into very fine droplets and dispersed in the other liquid. As a rule, the two liquids fall into the two classes

Oil and Water, since aqueous fluids do not dissolve in or mix with oily fluids to any appreciable extent. Normally, if petrol and water were mixed and shaken together vigorously, the mixture would separate on standing, into two layers, the petrol on top and the water below. But if one of the substances known as emulsifying agents were added, the petrol and water on shaking, would remain mixed for some considerable time; there would be no separation and the mixture would be milky and not transparent. This would be an emulsion.

Obviously there can be two classes of emulsion. In one, the oil is broken up into microscopic drops and dispersed in the water, and this would be known as an oil in water emulsion. Milk is the most familiar example of this, since it consists of fine drops of fatty material suspended in water. In the second type of emulsion, the water is dispersed in fine droplets in the oil. This is a water in oil emulsion, and butter is the best example since it contains fine drops of water suspended and dispersed in fat. In general, oil in water emulsions are aqueous or creamy in nature, while water in oil emulsions are fatty and greasy. In other words, an emulsion generally assumes some of the characteristics of the continuous phase, while the characteristics of the dispersed phase are marked. The use of many emulsions is due to this property.

On mixing an oily liquid with an aqueous one, either of the two types of emulsions may be formed, depending on a variety of factors. In general, the liquid present in the greater volume has the best chance of becoming the continuous phase, the smaller volume being more readily dispersed. The character of the emulsifying agent may favour the formation of one type of emulsion, and, finally, the manner of mixing or shaking may be important. It is not infrequent for an emulsion to "invert", that is, to turn from one type to the other under the influence of mechanical action. The churning of cream into butter is an example of this, cream being an oil in water, and butter a water in oil emulsion.

In any emulsion, it is essential that an emulsifying agent is present, though it need be present only in very small proportions. The best emulsifying agent is soap; and soap, or soap-like materials form the bulk of commercial emulsifying agents. It is because of this property that soap is so excellent a washing agent. Soap helps to remove the coherent layer of grease from clothes, and assists in its dispersion in fine droplets in the form of an emulsion. Dirty washing water is always translucent because of these fine particles of greasy matter dispersed in it.

There are other emulsifying agents, particularly in food and cosmetic emulsions. In foods, egg yolk is the commonest material, and is used for example in the emulsification of Olive Oil in vinegar in the manufacture of salad cream and mayonnaise. Flour and starchy materials have some emulsifying properties. It is because of this that fat can be stirred into gravy containing flour, and will remain suspended instead of floating on the surface.

Cosmetics usually include soap or allied materials to assist in emulsification. Oils, which in themselves might be distasteful, are emulsified in water, and the resulting cream has none of the unpleasant characteristics of the original oil, and yet all its virtues. It is for this reason that Cod Liver Oil is emulsified. Cod Liver Oil is unpleasant to take because of its taste and its greasy character. By emulsifying the oil in water a cream is formed which is not greasy, and in which the taste is masked by the dispersion of the oil in the water.

It will be noticed that these emulsions are chiefly of the oil in water type. Water in oil emulsions are less common as a rule, but they are used commercially. The most interesting one is margarine, which was designed as a substitute for butter. In margarine, edible fats and water are emulsified so that the water is dispersed in the fat, and this gives the familiar greasy solid. Water is present to the extent of

about 15% which is almost exactly the same amount as is found in butter. The similarity to butter is still further increased by the addition of vitamins, and from a food point of view, such an emulsion can be quite as wholesome and nutritious as butter.

A most interesting use for emulsions has just been discovered in connexion with the treatment of disease. It was found that lethal doses of Diphtheria or Tetanus toxins could be injected into the blood stream without fatal results if the toxin was first mixed with a 5% emulsion of Olive Oil in water. This suggested a method of treating bacterial diseases. The introduction of toxins into the blood stream normally produces two effects. The body manufactures anti-toxins to combat the toxin, and the toxin itself produces symptoms of a particular disease. If, however, the toxin is rendered harmless by emulsification, it produces only the first of these effects, and the anti-toxin thus formed will be able to combat toxins present through the influence of bacteria. Treatment on these lines has been successful in cases of Pneumonia, Diphtheria and Rheumatism. The mechanism of the action is not yet understood, but it is probably physical, and depends on the size of the dispersed oil particles rather than their nature. T. K.

The Age of Athens

First Mycenean Burial Discovered

THE excavations of the American School of Classical Studies at Athens on the Acropolis, which have now been in progress for nine seasons, have produced a number of discoveries of interest to students of the culture and art of the Greeks in the historic period; but it is only in the excavations of the present year that anything has been found which throws light on the interesting, and so far as Athens is concerned, obscure period of Homeric and Mycenean times. This discovery of transcendent importance for the prehistory of Attica, is in the form of a rock-cut chamber tomb, in which certain of the funerary offerings—a number of vases—are of the characteristic form and decoration of the third Late Helladic period, which is assigned to the first half of the fourteenth century B.C. The discovery was described by Professor T. L. Shear, of Princeton University, field-director of the excavation, in the *Illustrated London News* of 22 July.

The tomb was discovered in shallow deposits on the north slope of the Acropolis, and was of the usual type, in which the actual burial chamber is approached by a dromos or passage-way, from which the burial chamber is entered. In this instance the dromos was 6 ft. 6 in. wide at the base, narrowing to about 5 ft. at the top. Its length was 45 ft., but it may originally have been longer, as the outer end was cut by the Roman wall. Both burial chamber and dromos had been cut from the living rock. The entrance from the passage-way to the chamber was through a rock-cut doorway in the northern side of the chamber. This doorway had been closely and carefully packed with stones, which evidently had not been disturbed since they were first placed in position. The chamber when opened was found to

be filled with masses of splintered rock, but the passage was filled with earth and small stones, in which were discovered fragments of Mycenean potsherd.

Within the chamber benches had been cut from the rock of each of the walls. On one of these were six vases and a cylindrical ivory box, of remarkable size, technique and artistic design. These offerings were in their original position; but although the ivory box was intact, the vases had been crushed by the collapse of the roof. East of the doorway were two large vases standing by a copper ladle. The presence of the ladle is taken to indicate that the vases had contained wine for libation. The grave had been cut in the rock to a depth of 4 ft. The cover, a stone slab, had been removed from the grave, and lay in a diagonal position by the grave. There were neither bones nor offerings in the grave; but one small gold disc was found in the earth filling. On the floor beside the cover lay a group of small toilet objects—a bronze mirror, a small ivory box, and ivory pins; and on the floor, north of the grave, were three piles of gold ornaments.

The pottery is of a single period and is similar to that found at the Argive Heraeum and elsewhere. As already stated it dates the find to the late Third Helladic Period, which in terms of years is assigned to the first half of the fourteenth century B.C. The form and decoration of the pottery are characteristically Mycenean, as also is the carving in relief of the two ivory boxes, on one, the larger, griffins attacking a herd of deer, on the smaller a repeated nautilus design.

The condition of the tomb and the character of the offerings, as interpreted by Professor Shear, lead to an interesting conclusion, which throws an entirely new light on the character and extent of the Mycenean occupation of Athens. Hitherto the archaeological evidence for a Mycenean settlement here has been the scattered remains, near the Erechtheum on the Acropolis, of cyclopean walls, similar to those which have been found at Mycenae and on other sites of Mycenean age. Not only is the discovery made by the American School the first of its kind at Athens, but it necessitates a new orientation in assessing its importance as an early site.

The burial as a whole and the richness of the offerings indicate that this was the tomb of a lady (as shown by the toilet articles), who was probably a member of the royal house of Erechtheus, the legendary king who ruled Athens in the fourteenth century B.C. The wealth of gold offerings points to a community of considerable size and importance. Soon after the burial, the roof of the burial chamber seems to have collapsed. The chamber was then entered from above and the body removed, the grave being left uncovered. The offerings were taken from the grave at the same time, but in the hurry of removal some were overlooked. The chamber was then filled in with broken rock and earth and not used again for further burials, as was the more usual custom.

In the Homeric poems Athens plays but a small and unimportant part in the Trojan wars. If Professor Shear's interpretation be correct—probability is certainly on his side—it is evident that current opinion based on that evidence must be revised, at least in so far as it affects the period of five generations before the Trojan wars when Erechtheus was king in Athens.

E. N. FALLAIZE.

Plant Communities

By D. H. VALENTINE

WHOEVER lives or walks in the countryside is familiar with the common plants, and knows too that they live together in a definite way. He would be surprised, for instance, to find a gorse bush growing in the middle of a wood, for he would know that its usual place was not in woodland, but on a grassy heath. He is able, in fact, to recognize what are known as plant communities. The botanist speaks of woodland communities, grassland communities, and so on; and he qualifies these by adding the name of the most important plant as, for example, oak woodland, beech woodland, or by mentioning the type of soil on which they are growing, e.g. chalk grassland. There are many types of community, each with a character of its own, and each too has a structure; for example, in a forest there are the tall trees, forming as it were an upper layer of foliage, the smaller undershrubs forming an intermediate layer, and on the ground a layer of mosses and herbs. All these plants live together in harmony; each plant has adjusted itself to the needs of communal life.

Just as individual plants flourish, die and decay, so plant communities disappear, and give place to others; and just as an oak tree has a much longer span of life than a poppy, so some plant communities are short-lived, others apparently immortal. The replacement of one plant community, which decays, by another, is known as *succession*; the most stable plant communities are called *climax* communities. An example will make this clearer.

Let us suppose that a piece of pasture land is abandoned by man, and allowed to go wild. It is found that woody plants colonize the pasture. Frequent colonists are shrubs with fleshy, bird-dispersed fruits, such as hawthorn and rose. Eventually, after several years, the grassland community of the pasture disappears, and is replaced by a community in which the most important plants are shrubs, most commonly hawthorn. This is known as *succession* from grassland to scrub; scrub is not the final stage, for, provided suitable seed-parents are near at hand, tree seedlings make their appearance, and, in time, trees grow up. The most common tree colonizer is oak. The original hawthorn scrub gradually dies away as it is overshadowed by the taller trees, and an oak wood is formed.

The succession, diagrammatically, thus is:

grassland→hawthorn scrub→oak woodland (climax community).

The term *climax* community simply means that this community is stable under the existing conditions; that is, under these conditions, grassland tends to go to scrub, and scrub to woodland; but the wood is not transformed into anything else. It remains a wood.

It is believed, with good reason, that woodland of some kind is the climax community over practically the whole of the British Isles; in other words, if cultivation and the hand of man were removed from our countryside, it would, in the main, become woodland, going through a series of stages like those just described This is because the British Isles lie in a climatic zone which is suited to deciduous woodland; and climate is the factor which is most important in controlling plant com-

munities. If we move into a different climate, we find a different climax community. Climbing to the top of a mountain takes us to a climate very different to that of the lowlands; low temperatures and great exposure to wind are encountered. We know that at the top of our highest mountains, at 3000 ft., we do not find woodland; instead, the plant community often consists of little but a few scraps of grassland and scrub sheltering behind boulders. In such places, the climate is often so severe as to prevent the whole of the ground from being covered. Again, as we pass from the North Pole southwards, we go through a series of different types of climax vegetation; first the arctic tundra, then the evergreen forest of pine, and then the familiar deciduous forest of our own temperate zone.

Soil is an important, though not the primary factor, in governing vegetation. For instance, on a heavy clay soil, in this country, the climax community is woodland in which the most important tree is oak. On a chalky soil, however, in the south and east of England, although the climax community is still woodland, it is composed mainly of beech, and oak is practically absent. The stages of succession, too, are often different, e.g.

grassland→juniper scrub→beech woodland (climax).

The undershrub in the climax woodland is frequently yew, and not, as is so common in oakwoods, hazel, or less commonly, holly.

Fig. 1. *Loose scrub of hawthorn and dog rose colonising pasture, oakwood behind Gault Clay near Didcot, Oxon.* (R. J. L.)

This drift, as it were, of vegetation from grassland to woodland is, of course, checked by man and his domestic animals. Grazing animals soon eat away young shrub and tree seedlings, so that the first stages of succession to woodland cannot occur. The sheep pastures of the North and South Downs would probably revert to beech woodland if sheep, and rabbits, were removed. It is thus quite erroneous to suppose, that to leave a patch of land to itself is to obtain something which is of

Fig. 2. Dense juniper scrub on Chinnor Hill, Oxon., invaded by beech from the plateau above. (R. J. L.)

Fig. 3. Yew forming the undershrub layer in beechwood, at Duncton Down, Sussex. (R. J. L.)

Fig. 4. On the right of the rabbit-proof fence the turf is eaten down close to the soil. On the left the herbage is luxuriant. Cavenham Heath, Breckland. (E. P. Farrow)

Fig. 5. Two rabbits are seen (centre and left), uneasy in the presence of the photographer: many more were previously feeding on the area. The stems of the hawthorn scrub are bare up to the height a rabbit can reach. The white patches of chalk stones mark the sites of burrows. (R. J. L.)

interest to the naturalist and picturesque to the eye. Wicken Fen, near Cambridge, is the home of a great diversity of plants and animals, and it is maintained in its present state by the continuous and persistent interference of man. If Wicken Fen were left to itself, it would rapidly be overgrown with bushes, and eventually become woodland. It is only by continuous cutting down and uprooting of the bushes that its owners, the National Trust, are able to maintain the earlier and more interesting stages of the succession (corresponding to grassland in the other examples) with their varied vegetation and animal life.

Fig. 6. Oak wood at Killarney; holly forms the undershrub layer. (Mrs Cowles)

Rabbits as factors affecting vegetation are of great importance; their great numbers make them in many parts of the country a serious pest. Their action is, of course, similar to that of sheep and other domestic animals, in that their grazing prevents the establishment and development of tree seedlings. It is frequently necessary, when planting a forest, to surround the planted area with a rabbit-proof fence. The immediate effect of such a fence on various types of grassland has been demonstrated several times. Fig. 4 shows how, on one side of the fence, the vegetation is eaten down to the ground, and on the other has sprung up and made vigorous growth.

The study of plant communities is known as Plant Ecology; the best account of the ecology of British plant communities is to be found in A. G. Tansley's book, *The British Islands and their Vegetation*, from which the photographs illustrating this article were taken.

REVIEWS

RUTHERFORD

Rutherford. Being the Life and Letters of the Rt. Hon. Lord Rutherford, O.M. by A. S. Eve. With a foreword by Earl Baldwin of Bewdley. Cambridge University Press, 21*s*.

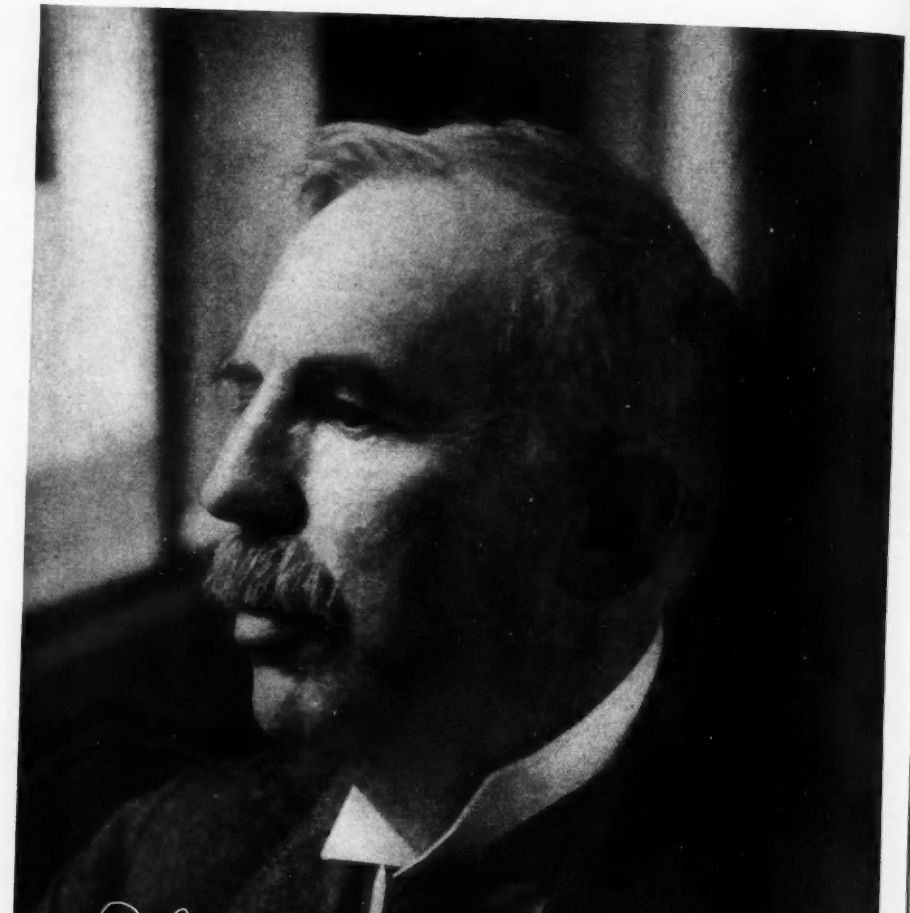
No great scientist has yet been the subject of a great biography. It is not altogether surprising; the actual creative work of great scientists is usually not easy to understand, and the explanation takes up a disproportionate amount of the written history; their lives are, almost by necessity, free from external drama; and, more serious than the other reasons, great scientists tend to be very ordinary people apart from their special gift, and seem in all ways decent, commonplace human beings who by pure chance have been given an unusual knack with numbers or imagination in playing with a piece of apparatus. One has to work much harder to get interested in their lives than in, say, the lives of great writers; and, as a rule, such interest as one does find is of a rather back-handed nature—as, for instance, when one reads of Willard Gibbs never moving from New Haven for year after year, attending dimly at Faculty meetings and putting in an unnoticed vote on the reactionary side, taking the same walk each morning and the same drive each afternoon, occasionally buying a lengthy, obscure publication in a journal that no one read; and happening to be, in a country where no one knew it, the most remarkable American of his age.

That is the kind of interest one is driven to in most scientific biographies: but Rutherford evokes something much more full-blooded. Professor Eve's is the official biography, compiled from Rutherford's own letters, written with the aid of the family and so, like any official biography, with the gloves on. Yet, even though Professor Eve is too kindly a person to cope completely with his monumental subject, he lets an impression come through of a man of mind and flesh, a man, who if he had never been a scientist at all, would still have made his mark upon the world.

Rutherford was, of course, a very great scientist. Of all experimental scientists, Faraday is the only one big enough to compare him with; and opinion most competent to decide is beginning to say that Rutherford is the greater of the two. An *advocatus diaboli* might perhaps argue that Rutherford was singularly lucky in his time, and that it is difficult to see how his particular kind of thinking could have been so startlingly successful if he had begun his career in 1935 instead of 1895: while Faraday, everyone admits, would have adapted himself to any period. But it is not a profitable controversy: their achievements will always exist, and we can go on arguing about them for ever.

Rutherford, was then, by universal admissions, one of the greatest of scientists. He was also a man of immense, vital personality. By the force of this personality, he took the whole world of academic physics under his paternal charge. In his later years, he had unbounded faith in his own powers. Most great men are not over-modest: Rutherford was far from being so. He revelled in being a prodigious success. He went rough-shod over the academic world and left a legacy of rollicking stories behind him. A very big man physically, with an enormous voice, capable of referring to 'my atom' at the top of that enormous voice, he produced an impression richer and more robust than that of any of his contemporaries. Impatient, hot-tempered, generous, he was spontaneous in magnanimity, spontaneous in his intolerances: he had no use for 'those fellows', a term of general abuse which included intellectuals, writers of philosophical popular science, and chemists. He was altogether a racy, complete human being.

There is one question that strikes anyone interested in his character. Was this legendary Jehovianic Rutherford of the later years really the whole man? Or was it, to some extent a



LORD RUTHERFORD

least, the facade assumed by a nature really unexpectedly sensitive and shy? He was certainly a far more highly strung and nervous man than most people knew; and it was one of the great merits of Professor Eve's biography that he gives us a chance to see the inside of the man before he behaved as though he was certain of himself. C. P. S.

The Study of Vegetation

A review of "The British Islands and their Vegetation," by A. G. Tansley, pp. 930 + xxxviii with 418 photographs and 179 figures in the text. Cambridge University Press, 45s.

The British Islands and their Vegetation, which has just been published by Professor Tansley through the Cambridge University Press, is a book of great importance, and must attract the attention and study of a very wide range of readers. This is because it represents a long-delayed summary of the progress of a young and vital subject of scientific research carried out by a school of British investigators since the early part of this century.

The subject of "Plant-ecology" is no more than the scientific study of the plant in the natural conditions under which it grows: it represents "nature-study", reinforced by scientific methods of observation, experiment and statement. The botanist who turns to ecology comes to it prepared to apply the different techniques learned in many different fields of botanical investigation. He needs a knowledge of taxonomy to identify species and varieties of plants exactly; he needs knowledge of plant-physiology since the success or failure of plants is determined by the way in which their natural processes operate; he needs knowledge of soil and its formation, of plant structure, of the mechanism of seed-production and hybridization. In fact, not one of the fields of botanical investigation but has its relation to scientific field-studies.

Some ecological studies have concerned themselves with the problems raised by single species, such as those described in earlier articles in *Discovery* on the butter-burr (Vol. II, no. 14, May 1939) and the lesser celandine (Vol. II, no. 15, June 1939), but the mass of ecological work in this country has so far dealt with the plant *communities* which make up the vegetational cover of our country. It will be clear to everyone that plant communities like human communities exist and have recognizable unity and individuality. The language of everyday life accepts the terms "woodland", "heath", "fen", and "bog" in implicit recognition of this fact. Within the woodland we confidently expect to

Gorse and hawthorn from *British Islands and their Vegetation*

find certain species with great or fair regularity. Thus the oak-wood on sandy soil may contain an under-storey of hazel, and below it bracken, bluebells and soft grass, with honeysuckle as a climber. These species live together because their requirements interlock, because the lower growing species will tolerate the shade and food-competition and other effects of the dominant oak, presumably among other things, because the flowering or leafing times do not conflict, and because their rooting depths are not the same. In addition to this all the species mentioned must tolerate the general climatic conditions and the particular soil conditions when the wood is growing.

It has been the task of British ecologists for the past 30 years or so to elucidate such relationships as this much-simplified illustration offers, for all the chief plant communities of the country. They have attempted, with some success, to explain the mosaic of natural and semi-natural vegetation of Britain in terms of the climate, and soil, and topography which prevail in different parts. At first their studies were isolated and tentative, but in 1904 a British Vegetation Committee was formed to coordinate and develop the survey of our native vegetation. By 1911 enough had been done to allow the members to produce, under the editorship of Professor Tansley, a book called *Types of British Vegetation* which became the standard reference for this subject, and which, when out of print, was for long years not purchasable second-hand at less than two or three pounds, despite its original price of only a few shillings. Since this book appeared the subject has advanced enormously, and no conspectus of it has been attempted until now, when the same editor presents what may fitly be called his life-work, in a great volume of over 900 pages with almost 600 illustrations. It may well be called Professor Tansley's life-work for he was the first President of the British Ecological Society which was formed in 1913 from the old British Vegetation Committee, and he edited the *Journal of Ecology* for that society through 20 years of successful establishment and expansion. Throughout he has played a very large part in directing the course of British ecology, and in this book he collects and reviews all the work upon it that has so far appeared, coordinating it or bringing it, through his own extensive knowledge of our vegetation, into a consistent pattern. As always he writes with great fluency and directness so that the book is a pleasure to read, and the photographs which illustrate the book have been chosen and reproduced with the greatest skill, so that they add enormously to the usefulness and attractiveness of the volume.

It would be quite impossible to give in so short an account as this any detailed account of the contents of the book. It begins with an extensive treatise on the British climate which gains greatly in interest by its original treatment of factors that bear closely on plant life but are seldom otherwise considered, and by a division of the British Isles into separate climatic regions. Topography, geology, and soil structure are dealt with thoroughly, so that the reader may visualize the complex of factors which determines the pattern of our natural vegetation. In fact, of course, the greater part of the present vegetation of the British Isles bears the strong impress of man's activities, either direct, or operating through the animals man has introduced and domesticated. It is now becoming possible, through the study of peat deposits in our fens and bogs, to reconstruct something of climatic and vegetational history in the prehistoric period, and a summarized account of this precedes an account of vegetation changes our forefathers caused during historical times. The first quarter of the book also includes a clear account of the principles of vegetational study and nomenclature as employed in Britain. The remainder of the book is concerned with extremely interesting and well illustrated accounts of all kinds of British vegetation. It includes woodlands and grasslands of many kinds, the aquatic communities of rivers, lakes, fens and bogs, the vegetation of heath, scree, mountain-top, sand-dune, shingle-bank and salt-marsh. Anyone who loves our countryside, however modest he may feel his botanical knowledge to be, cannot fail to be excited and held when he has once opened this book. It is the happiest opening to a period in which we shall see ecology play an increasing part in the scientific and social life of the country.

H. GODWIN

The Quiet World of Nature

Mr Gooch's book* came to me for review in the ten days before the outbreak of war, a time when I had, unfortunately, to be away from home, so I put it in my bag to read in spare moments. The book became a refuge for me at that period of nervous tension, and since the foolishness of war is now upon us, I feel there must be many more readers who, possibly denied the restful quality of the "quiet world of nature", will find moments of peace and relaxation in the pages to which Mr Gooch has given that title. The prose is sensitive and sometimes beautiful, with no straining after effect. Here is a book of twenty-two short essays in natural history; each one is the fruit of experience and frankly anecdotal. But Mr Gooch sees his animals as animals and not as travesties or caricatures

* *The Quiet World of Nature*, Bernard Gooch; John Lane, The Bodley Head; 8*s.* 6*d.* net.

of human beings. He is an extremely careful observer, whose attention to detail in describing animal behaviour makes his work a worthy source book for the serious student. Mr Gooch is a naturalist of the new age which prefers fact in nature to tell its own beauty rather than hide it in the fog of anthropomorphism. His patience is endless in caring for some of the wild creatures which have come into his hands.

Take for example, *The Biography of a Salamander*: Mr Gooch acquired a spotted salamander from a London dealer—the London slave market, as he says—and it developed a chronic sore in the mouth. Such an infection is usually fatal, but this individual creature was fortunate in its protector, who painted the sore with disinfectant twice daily for eleven months. He has kept this female batrachian for over twelve years and has gained sufficient knowledge to keep her contented and to rear a family from her—no mean achievement. Adders and grass snakes have also been among Mr Gooch's pets and his facility in handling wild adders rivals that of W. H. Hudson.

Again, *Herbert the Herring Gull*, is a delightful chapter describing the early weeks, months and years of a gull chick which Mr and Mrs Gooch picked up at one day old from the bottom of some chalk cliffs below an extensive herring gullery. This bird became one of those almost human creatures in avian dress which are rarely other than pathetic in the long run. Few of us can live without a certain amount of travelling and absence from home, and it is then we find our wild pets cannot be just left to fend for themselves. Mr Gooch's gull escapes tragedy by going to the London Zoo, where it can enjoy a large measure of freedom and plenty of human company. This essay is one of the finest in the book.

Other essays treat Mr Gooch's Dartmoor garden and a Devon estuary as places in which birds live and through which they pass, a method that much excels any momentary description of such habitats.

Of the photographic illustrations, I like best the landscape studies, and especially the Frontispiece of Dartmoor.

F. FRASER DARLING

Select List of Books Received by *Discovery*

(*Mention in this list does not preclude review*)

Great Flights. E. COLSTON SHEPHERD. (A. and C. Black, 7*s*. 6*d*.)

Polar Exploration. ANDREW CROFT. (A. and C. Black, 7*s*. 6*d*.)

The Social Institution of the Kipsigis. J. G. PERISTIANY. (Routledge, 18*s*.)

The Native Races of America. Vol. IV. (Percy Lund Humphries, 35*s*.)

Geology of South Africa. ALEX L. DU TOIT. (2nd ed.) (Oliver and Boyd, 28*s*.)

The Restless Earth. R. GHEYSELINCK. (Scientific Book Club, 2*s*. 6*d*.)

Mankind in the Making. M. CATHCART BORER. (Frederick Warne and Co., 3*s*. 6*d*.)

Archaeology and Society. GRAHAME CLARK. (Methuen, 7*s*. 6*d*.)

The Fate of Homo Sapiens. H. G. WELLS. (Secker and Warburg, 7*s*. 6*d*.)

Rutherford. A. S. EVE. (Cambridge University Press, 21*s*.)

Young Chemists and Great Discoveries. JAMES KENDAL. (Bell, 7*s*. 6*d*.)

Science Marches On. WALTER SHEPHERD. (Harrap, 8*s*. 6*d*.)

A Text Book of Quantitative Inorganic Analysis. ARTHUR I. VOGEL. (Longmans, 18*s*.)

Text Book on Light. A. W. BARTON. (Longmans, 8*s*.)

A Text Book of Heat. Part II. H. S. ALLEN and R. S. MAXWELL. (Macmillan, 10*s*. 6*d*.)

Matter and Light. The New Physics. (George Allen and Unwin, 12*s*. 6*d*.)

Practical Physics. W. F. F. SHEARCROFT and J. H. AVERY. (Heinemann, 8*s*. 6*d*.)

Journals

In addition to the regular exchange journals, the following have been received:

Irish Journal of Medical Science.

Occupational Psychology. Vol. XIII, no. 4.

Prospectus of University Courses in the Municipal College of Technology, Manchester, Session 1939–40.

The photographs illustrating Mr D. S. Evans's article on telescopes in the October number should have been acknowledged to the Warner and Swasey Co. of Cleveland, Ohio.

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SIR ARTHUR EDDINGTON'S answer to those who assert that there is no philosophy of science, but only the philosophies of some scientists, may be read in *The Philosophy of Physical Science* (8*s.* 6*d.* net). Sir Arthur examines the philosophic principles implicit in the *practice* of modern physics, and outlines a general philosophy which a scientist can accept without inconsistency.

READ "Eat and Keep Young", 3*s.* 6*d.* Fruitarian Society, Doddington, Kent.

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